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IN THE

Supreme Court of the United States

OCTOBER TERM, 1930.

DEFOREST RADIO COMPANY,
Petitioner,

v.

GENERAL ELECTRIC COMPANY,
Respondent.

No. 630.
Langmuir Patent
1,558,436.

ON WRIT OF CERTIORARI TO THE CIRCUIT COURT OF APPEALS FOR THE THIRD CIRCUIT.

BRIEF ON BEHALF OF RESPONDENT.

Opinions of the Courts Below.

The opinion of the Court of Appeals of the District of Columbia awarding priority to Langmuir in the Patent Office interference between Langmuir and Arnold of the American Telephone & Telegraph Company is reported at 6 Fed. (2d) page 704 (Op. p. 91). The opinion of the trial court holding invalid the Langmuir patent is at 23 Fed. (2d) 698 (Op. p. 96). The memorandum decision of the Circuit Court of Appeals for the Third Circuit affirming the decision below, Judge BUFFINGTON dissent-

ing, is not reported, but is at Vol. III, page 2007 and at (Op. p. 125). The opinion of the same Court on rehearing, sustaining the patent, by Judges BUFFINGTON and DAVIS, Judge WOOLLEY dissenting, is reported at 44 Fed. (2d), page 931 (Op. p. 126).

Statement of the Case.

Subject-matter involved.

The invention is an improvement in electrical vacuum discharge devices of the type known as "hot cathode" tubes, in which current flows through an evacuated space from a heated cathode called the filament to a cold anode called the plate. The modern radio tube is a familiar example of such a device.

As stated in the specification, the tubes of the patent are distinguished by the regularity and reproducibility of the current, as contrasted with prior art hot cathode devices in which the current was irregular and non-reproducible. This difference is due to a difference in the type of the electrical discharge; the tubes of the patent operate by what is termed "pure electron discharge," as distinguished from the prior art devices in which the conduction of current depended upon "gas ionization."

The petitioner (defendant below) admits infringement of every claim of the patent (Vol. I, p. 39). In its attempt to defeat the patent it resurrects the prior art tubes which long ago it discarded, but now asserts are the identical devices of the invention.

The first practical radio tube was the Fleming valve, a two electrode tube.

DeForest improved upon Fleming's valve by adding a third electrode which he called the "grid." He called this device an "audion." It was an improvement upon, but an

infringement of, the Fleming valve (*Marconi* v. *DeForest*, 243 Fed. 560).

Counsel for petitioner say that the three electrode tube revolutionized the electrical arts. It was not DeForest's audion which did these things. It added very little, if any, impetus to the art; so little in fact that until after Langmuir's invention, crystal detectors were used in preference to DeForest audions in such an important station as the Government Station at Arlington (I. R. p. 1602). It was Langmuir's tube which as Judge MORRIS said,

> "because of its stability, reproducibility and power, has made possible radio broadcasting, modern radio reception and long-distance telephony" (Op. p. 106).

One great trouble with the DeForest audion was that it was erratic and tricky; no two audions acted alike and no one audion would act the same way very long. As DeForest himself said in 1915 (I. R. p. 1502):

> "In the first place, anyone who has had considerable experience with numerous audion bulbs must admit that the behavior of different bulbs varies in many particulars, and to an astonishing degree. The wing (plate) potential-wing (plate) current curves for different bulbs, or even for the same bulb at different times, under different conditions (filament temperature, etc.) vary widely.
>
> "What may appear to be a fixed law for one bulb may not hold for another."

This is the kind of device which petitioner made and sold before and for some years after Langmuir's invention. In 1919, however, it discontinued this type of tube and announced the adoption of a new type, which it described in a trade bulletin as follows (Vol. 4, p. 158):

> "The chief difference between this tube and the type T tube of similar mechanical construction is in its evacuation. The old style type T was an ionic or gaseous tube very unstable in operation and requiring a variable 'B' battery. It had the decided disadvantage that after continued use the tube would get 'hard' and require more 'B' battery until it reached such a state as to be inoperative. The new 'VT' tube, like the DeForest standard tubes to-day, is purely an electronic tube exhausted to a very high vacuum, so that it is nongaseous and will stand very high plate potentials. When used as a detector, however, a battery of from 20 to 40 volts is sufficient to give a proper plate current, although voltages of 80 to 100 may be used without detrimental effect upon the tube. The 'B' battery moreover, is not critical in adjustment and, therefore, a fixed battery may be used and is used for all practical work."

In the same bulletin petitioner stated (Vol. 4, p. 159):

> "The old type gaseous tube with the candelabra base can be used similarly, except that a variable 'B' battery of from 20 to 50 volts is required. The gaseous type tubes are, however, no longer being manufactured."

The new tube which petitioner described as "purely an electronic tube" is the Langmuir tube. The "old type gaseous tube" which was "very unstable in operation and requiring a variable 'B' battery" and which "had the decided disadvantage that after continued use the tube would get 'hard' and require more B battery until it reached such a state as to be inoperative," is the audion which is now presented as a complete anticipation of the invention.

The critical adjustment of the B battery voltage to which the bulletin refers is characteristic of gaseous

tubes, and is a reliable test to determine whether a tube is operating by gas ionization. It will be helpful to remember this when the Court comes to consider petitioner's argument that the DeForest audions were not gaseous tubes.

What the patent purports to cover.

Counsel for petitioner have entirely misapprehended, or at least misstated, our position. The invention is not a mere matter of vacuum; as Judge BUFFINGTON said in the opinion of the Court (Op. p. 141):

> "But a vacuum, or indeed change of vacuum, isolated and standing by itself, is not the Langmuir invention, but it is a working tube in which all the elements, cathode, plate, vacuum, so coordinate and interwork that current flow is not affected by gas."

This is and always has been our position. The thing which distinguishes the tubes of the patent from similar devices of the prior art is not the vacuum, but the type of the discharge. The invention is a tube in which the current is uniform, predictable and reproducible at any voltage, because it does not depend upon gaseous conduction, as contrasted with the DeForest audion, which as we have seen, was "very unstable in operation" because the conduction of current depended upon gaseous ionization. The vacuum in a Langmuir tube is important only as one of the elements which in proper combination produce the desired result, and this is precisely what the patent teaches us.

Nor do we contend "that any DeForest audion (except a 'detector' tube) which properly performs its intended function, is covered by the Langmuir patent." On the

contrary, this is the petitioner's position. Our position is that a DeForest audion, whether a detector or amplifier, when properly performing its intended function, depended upon gas ionization; this was the thing that made it tricky, but it was also the thing that made it work. The difference between a Langmuir tube and a tube operating by gas ionization is not that one will work properly and the other will not, but that when both are properly performing their intended functions they operate in entirely different ways because they depend upon different principles of operation.

Scientific principles involved.

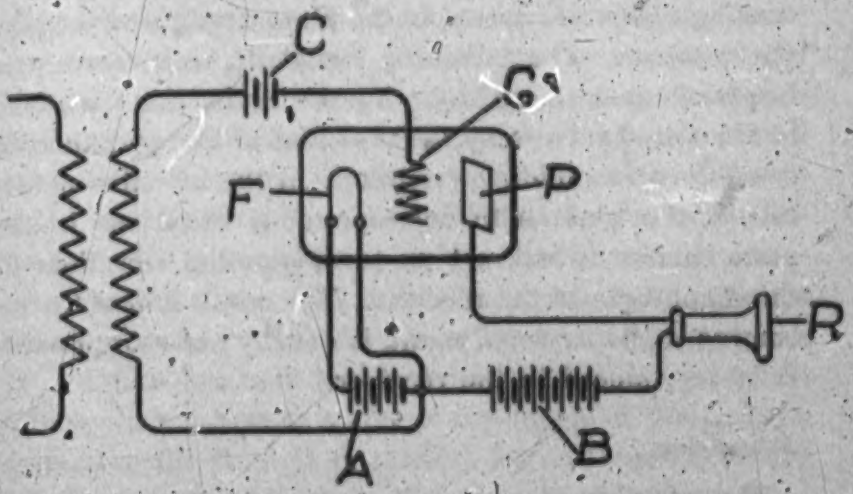
To understand the difference in principle of operation between a Langmuir tube and a DeForest audion the Court must understand the difference between a pure electron discharge and a discharge through ionized gas, and how this difference is manifested in the action of the tubes. While the petitioner's explanation of the scientific principles involved is reasonably accurate as far as it goes, it is entirely inadequate, and the statement "that the amount of the gas residue *permissible* in any particular tube depends upon the use to which the tube is to be put and the voltage under which it must operate" is ambiguous and misleading.

The amount of gas "permissible" in a tube operating by gas ionization is one thing; the amount of gas "permissible" in a tube if it is to operate by pure electron discharge is something quite different, and this is true even though the two tubes are put to the same use and operate under the same voltage.

As this is a matter of controlling importance we shall take the liberty, at the risk of repeating some things which have been correctly stated by the petitioner, to

explain first the general principles of operation common to both types of tubes, and then to point out the difference in principle of operation between a Langmuir tube and a DeForest audion *when put to the same use and operating at the same voltage.*

The principle of operation of a radio tube.



In a radio tube of the audion or three-electrode type we have an evacuated bulb, inclosing a cathode or negative electrode (F) called the filament, an anode or positive electrode (P) called the plate, and a third electrode or grid (G) between the filament and plate. The filament is heated to incandescence by passing a current of electricity through it. In battery-operated sets, this current is supplied by the A battery; its sole function is to heat the filament. Another battery, commonly called the B battery, is connected between the filament and plate, the negative pole to the filament and the positive pole to the plate. When used as an amplifier, a telephone receiver (R) or loud speaker is inserted in the circuit between the battery and the plate. This is called the plate or out-

put circuit. A third battery, commonly called the C battery, may be connected between the filament and the grid. This is called the grid or input circuit.

When the filament is lighted, electrons or negative charges of electricity are boiled out of the filament, and these being attracted by the positive potential or pull of the plate, are carried across the tube to the plate, causing a flow of current in the plate circuit and through the receiver. The incoming signal or voice current is imposed upon the grid or input circuit; the variations of the sound wave vary the potential of the grid, thereby causing corresponding variations in the effective potential of the plate with corresponding variations in the plate current, which set up corresponding vibrations in the diaphragm of the receiver. The result is that the incoming signal or voice sound is exactly but more powerfully reproduced in the receiver.

Saturation.

The number of electrons emitted by the filament is determined by the temperature of the filament. This is known as Richardson's Law. But the current delivered by the tube depends not upon the number of electrons emitted, but upon the number of electrons drawn across the tube to the plate, and this varies with the voltage. When the voltage is sufficiently high to draw all of the electrons emitted from the filament to the plate, the tube is said to be saturated. When a tube is saturated no further increase in voltage will affect the amount of current, and therefore in this range, which is called the saturation range, the current will not respond to changes in voltage. As the operation of a radio tube depends upon this very response to changes in voltage, it follows that a radio tube is always operated in the range below

saturation, and this is the range with which we are particularly concerned. When a tube is operating within this range, it is said to be operating on the "space current."

Ionization.

If there is any appreciable residual gas in the tube, or if during the operation of the tube gas is evolved from the parts of the tube, the passage of the electrons from the filament to the plate at voltages in excess of the so-called ionization voltage, causes the gas molecules to disintegrate. This is called ionization. Ionization occurs at definite voltages, varying somewhat with different gases, but the evidence shows that it *begins* to be important as a factor influencing the flow of current somewhere between 20 and 30 volts. The physical phenomenon is rather complicated, but it is sufficient for the purposes of this case to know that when ionization is present in a tube, the gas acts as a sort of conductor of the current, *increasing* the current to a value beyond what it would be at the same voltage in the absence of ionization.

The result is that in a gaseous tube saturation is reached at lower voltages than in a non-gaseous tube with the same filament emission, but in the range above ionization and below saturation, which as we have seen is the range in which a radio tube is always operated, a gaseous tube, because of the increased current due to ionization, is more responsive to slight changes in voltage. Therefore, a gaseous tube is more sensitive, both as a detector and as an amplifier, than a non-gaseous tube, but its range of operation is more limited (Vol. 2, p. 1261).

A more serious objection, however, is the erratic behavior of such a tube. If gas is evolved from parts of the tube the pressure is constantly changing; moreover the pressure is not the same in any two tubes. As the amount

of ionization varies with the pressure of the gas, and as the conductivity of the gas varies with the amount of ionization, the current varies in different tubes, and in the same tube at different times. Moreover as it was desirable to operate a gaseous tube just below the point of saturation in order to obtain the maximum effect of ionization in the conduction of the current, it was necessary to adjust the B-battery voltage for each tube and for the same tube at different times to compensate for the varying conductivity of the gas and to keep the tube within its operating range. This accounts for the critical adjustment of the B-battery voltage, which as we have seen (p. 4) was characteristic of gaseous tubes.

Judge WOOLLEY had an entirely wrong idea of ionization. He speaks of the ions fighting the electrons and of gas as an enemy of conduction. The ions do not fight the electrons; they keep the electrons from fighting among themselves; they "police" the electrons, according to page 9 of petitioner's brief; gas is not an enemy of conduction, it is a friend of conduction, but an erratic and unreliable friend.

Blue glow.

Blue glow is associated with ionization, but the terms are not interchangeable. At any such voltages as those at which DeForest worked, blue glow is a visible sign of extreme ionization, occurring at about the point of saturation (Vol. 3, p. 1713). In this condition manifestly the tube will not operate as a radio tube.

Blue glow does not mark the *beginning* of ionization; ionization begins at the ionization voltage; blue glow occurs at some higher voltage, varying with the pressure of the gas (Vol. 3, p. 1718; Vol. 2, p. 1247). Within this range the current is influenced by ionization, increasingly

so as the voltage is raised to that at which blue glow occurs, and as we shall see, the best results were obtained with a gaseous tube when the voltage was critically adjusted to that just below the point at which blue glow occurred.

The point we wish to make clear is that absence of blue glow is no indication that the current is not affected by ionization. The mere fact that a tube operates at voltages above ionization voltage without evidence of blue glow is no indication whatever that the current is not substantially affected by ionization. We emphasize this statement because both Judge WOOLLEY and Judge MORRIS were evidently confused on this point.

The audion was always operated below the blue glow point, but it always operated by ionization, whether as a detector or as an amplifier. It was, as we shall see, ionization that made DeForest's audions such sensitive amplifiers; when they broke into blue glow they failed to operate (Jewett, Vol. 1, p. 411), but very substantial ionization existed in the DeForest audion without blue glow, as appears from the testimony of defendant's expert Chaffee at Vol. 1, page 274, and from the testimony of Hogan at Vol. III, page 1723, who says that the ionization sharply affects the current in an audion "long before the energy in the ionization discharge will cause a visible blue glow."

Pure electron discharge.

If the tube is so prepared and proportioned, that is to say, if the parts are so thoroughly freed of occluded gas that no gas is evolved during operation, and if the vacuum and the relation of the electrodes is such that no appreciable ionization takes place when the tube is

operated at voltages substantially in excess of ionization voltages, we then have what is known as a "pure electron discharge" tube. As the patent tells us (Vol. IV, p. 3, lines 110-114):

> "As distinguished from discharges in the presence of positive ionization, the pure electron discharge is characterized by regularity and reproducibility with given conditions."

The given conditions are the filament temperature and the B battery voltage, both of which may be predetermined. With a given filament temperature the current is determined solely by the B battery voltage. The result is that the tube is reproducible, by which we mean that the tube will operate the same way, day after day, and may be replaced with another tube which will operate the same way, without any adjustment of the A battery rheostat or the B battery voltage.

It is clear from the foregoing that the difference between a tube operating by pure electron discharge and a tube operating by gas ionization is a difference in the essential nature of the electrical discharge.

It is equally clear that this difference is evidenced by the fact that tubes operating by pure electron discharge will operate at a fixed B battery voltage, whereas tubes operating by gas ionization require critical adjustment of the voltage.

This is precisely the difference which the DeForest bulletin (Vol. 4, pp. 158, 159) points out between the old style gaseous audion and the new purely electronic tube when put to the same use and operated at the same voltage. "The old type gaseous tube * * * can be used similarly except that a variable 'B' battery of from 20 to 50 volts is required" (*supra*, p. 4).

Stability and reproducibility in a tube are matters of enormous practical importance. The modern radio receiving sets with six or more tubes in complicated circuits; the modern telephone relay; the modern X-ray tube, have been made possible only because of the absolute uniformity and reproducibility of the tubes. Such development would have been impossible with tubes which required constant and critical adjustment of the B-battery voltage. It would be impossible for instance to have a modern radio receiving set with six or more tubes each requiring constant and critical adjustment of the B-battery voltage, and requiring a different adjustment every time a tube was replaced.

The methods of getting high vacuum.

The idea that any useful flow of current could be obtained in the absence of gas was opposed to the general belief and experience of the art. Moreover, the preparation of such a tube involved problems new in the art. It was not simply a matter of pumping a very high vacuum which would be destroyed by the evolution of gas when the tube was operated; the new and difficult problem was to get all the gas out of the parts of the tube so that there would be no further evolution of gas during the operation of the tube.

The petitioner says that all this was old in the art. The fact nevertheless remains that no one before Langmuir produced such a tube. The inference is irresistible that the art did not know how.

History of the Langmuir application.

The petitioner seeks to create the impression that the patent as it issued covered an invention entirely different

from that originally claimed when it was filed, and quotes Judge WOOLLEY's opinion to that effect.

The suggestion is not justified by the facts. The same argument was made by Arnold in the interference proceeding and was overruled by the Law Examiner (Op. p. 15) and by the Board of Examiners in Chief (Op. p. 62).

Langmuir's patent application was filed October 16, 1913. It was entitled: "Electrical Discharge *Apparatus* and the Process of Preparing the Same" (Vol. VI, p. 662). As the Law Examiner of the Patent Office held in Arnold's motion to dissolve the Arnold-Langmuir interference (Op. p. 1), and as is evident on comparison of the original specification at Vol. VI, pages 662-673, with the final specification of the patent (Vol. IV, p. 2), the application as filed fully disclosed the new tube which Langmuir had invented and the process of preparing and producing it. The original claims were process claims; but product claims were introduced by an amendment filed two months later, December 28, 1913, *prior to any action by the Patent Office*. One of these claims reads (Claim 8, Vol. VI, p. 676):

> "A high vacuum electron discharge device comprising an envelope, an incandescent cathode, and an anode, the space in said envelope being evacuated to such degree that the current produces no appreciable positive ionization when the impressed voltage is as high as 200 volts."

Claim 11 of the patent as issued reads:

> "A high vacuum electron discharge device comprising an envelope, an incandescent cathode, and an anode, the space in said envelope being evacuated to such degree that the passage of current

produces no appreciable positive ionization when the impressed voltage is as high as 200 volts."

Moreover every one of the claims of the patent as issued reads directly on the invention as it is described in the original specification.

On October 18, 1913, two days after the filing of the patent application, Langmuir presented before the American Physical Society, a paper which was published in the December, 1913, issue of the Physical Review (Plaintiff's Exhibit 21, Physical). This paper contains a full disclosure and explanation of the invention (I. R. pp. 1595-1596).

Langmuir understood well enough what his invention was. His patent solicitor seems to have had trouble in drawing claims which would accurately define the invention in Patent Office language. That is an entirely different matter. It accounts for the fact that the application after being at issue in 1915, was allowed to forfeit. But it was promptly renewed, and in following this practice, respondent's solicitor was merely availing himself of the right which the Patent Statutes gave him (*U. S.* v. *Bell Telephone Co.*, 167 U. S. p. 224, at pp. 246-247), and following the usual Patent Office practice.

Petitioner insinuates that respondent is in some way responsible for the delay in the final issue of the patent. The facts do not warrant any such insinuation. Arnold filed an application for the same invention on November 2, 1915. On November 18, 1915, Arnold's attorney wrote to the Patent Office calling attention to Langmiur's application and suggesting an interference (I. R. p. 19). The interference was declared August 8, 1916. Proceedings in the interference were suspended during the war at the request of the Secretary of the Navy (Vol. 4, p.

209). With the exception of this interruption, the proceedings were conducted certainly with as much dispatch as is usual in such cases. Certainly respondent is not chargeable with the delay in the issuance of the patent after Arnold's application was filed, any more than it is chargeable with the delay of six years in reaching a final determination of the validity of the patent in this suit.

Arnold interference.

On November 2, 1915, Arnold of the American Telephone & Telegraph Company filed his application for a patent on the same invention. After an interference was declared, Arnold moved to dissolve the interference on the ground that the invention was not patentable. Every conceivable prior art reference was cited, and nearly two thousand pages of testimony were taken on the motion to dissolve. After careful consideration the Law Examiner concluded that the invention was novel and entitled to patent protection (I. R. pp. 2462-2471).

Thereupon the interference was proceeded with, the case being carried to the Court of Appeals of the District of Columbia, and resulting in a finding by that Court that Langmuir was the first inventor.

The defense of priority in the present case was conducted by the Telephone Company, which appeared by its own counsel and with its own witnesses (Vol. 1, p. 399).

Summary of Argument.

We shall confine the argument to an answer to the petitioner's six points, rearranging the order to correspond to what we conceive to be a more logical method of presentation. For the convenience of the Court we

shall indicate under each heading the point of the petitioner's brief to which the argument is addressed.

1. The definition of the invention adopted by the majority of the Court is the definition which is found in the specification and the claims of the patent. It is not, as petitioner asserts, a new definition advanced for the first time on the motion for reargument; on the contrary it is the definition which respondent urged at the trial and in the argument before the trial court, and in the brief originally filed with the Circuit Court of Appeals.

In the practical prior art devices the conduction of current depended upon gas ionization; the art moreover believed that unless there was enough gas to act as a conductor no current could flow and the tube would not work, and experience seemed to confirm this belief. In simple language Langmuir's invention consisted in taking out the gaseous conductor upon which the prior art relied and putting nothing in its place. (*Petitioner's second point.*)

2. The invention is not merely a DeForest audion capable of operating at higher voltages. The essential difference is that at any voltage the tubes of the patent are stable and reproducible, as contrasted with the audion which was always erratic and non-reproducible. The invention is not a vacuum or degree of vacuum; the vacuum is important only as one of the elements of a combination which produces a new, useful and unexpected result. Such a tube was new in the art and required new and different vacuum technique to produce it. The old tubes operated on the old principle of ionic or gaseous conduction; the new tubes operate on the new principle of pure electron discharge. (*Petitioner's first point.*)

3. The audions relied upon to prove the defense of prior use were gaseous tubes operating by gas ionization. The fact that a tube may amplify at 40 volts or more is no indication that it is a pure electron discharge tube, and the uncontradicted evidence shows that the tubes in question were gaseous tubes. DeForest had no idea of a pure electron discharge; his own statements show that what he wanted was a gassy tube; a tube exhausted to a particular optimum gas pressure in order to utilize the maximum useful effect of ionization. (*Petitioner's fourth point.*)

4. The question of priority was decided by the Patent Office tribunals in favor of Langmuir in a contest between the respondent and the American Telephone and Telegraph Company, which has openly defended the present case on this issue. The case for the patent has been strengthened, not weakened, by the evidence in the present suit. Langmuir made the invention when he made and operated a pure electron discharge tube in August, 1912, more than two months before Arnold's alleged date of conception. Arnold's whole idea was to take a DeForest audion and by pumping a better vacuum to extend the range of operation to somewhat higher voltages without modifying the essential nature of that operation. This is not the invention. His conception and disclosure were inadequate in that they did not include any adequate idea of means. The inadequacy of his conception is evidenced by his inconsistent statements and by his inability to make good tubes until after Langmuir's invention was disclosed to the public. (*Petitioner's third point.*)

5. The testimony on the defense of prior use was taken by deposition and not before the trial judge. The issue of priority depends not upon questions of fact but upon

inferences to be derived from facts which are substantially undisputed. The rule that the finding of the trial judge on disputed issues of fact will be treated as unassailable, therefore, has no application in this case. (*Petitioner's fifth point.*)

6. The defense of double patenting has not been sustained by any judge who has heard this case, and is utterly without merit. (*Petitioner's sixth point.*)

ARGUMENT.

POINT I.

The definition of the invention adopted by the majority of the Court is the definition which is found in the specification and the claims of the patent. It is not, as petitioner asserts, a new definition advanced for the first time on the motion for reargument; on the contrary, it is the definition which respondent urged at the trial and in the argument before the trial court, and in the briefs originally filed with the Circuit Court of Appeals.

In the practical prior art devices the conduction of current depended upon gas ionization; the art moreover believed that unless there was enough gas to act as a conductor no current could flow and the tube would not work, and experience seemed to confirm this belief. In simple language, Langmuir's invention consisted in taking out the gaseous conductor upon which the prior art relied and putting nothing in its place. (Petitioner's second point.)

Definition of the invention.

As we have seen, the definition which the Court below adopted was (Op. p. 141):

> "But a vacuum, or indeed change of vacuum, isolated and standing by itself, is not the Langmuir invention, but it is a working tube in which all the elements, cathode, plate, vacuum, so coordinate and interwork that current flow is not affected by gas."

This is precisely what the patent says; for example, Claim 2, which Judge WOOLLEY accepts as typical, reads:

> "2. A discharge tube having a cathode adapted to emit electrons and an anode adapted to receive said emitted electrons, the tube walls being fashioned or shaped to permit the direct passage of a useful proportion of said electrons from cathode to anode, the gas content or residue of said tube and the relation of the parts of the tube being such that the tube is capable of being so operated in a range below saturation and materially above ionization voltages that the space current is governed or limited by the electric field of said electrons substantially unaffected by positive ionization."

Confining ourselves to the specification as originally filed in order to meet petitioner's suggestion that the invention underwent some change during the progress of the patent through the Patent Office, we find the invention described as follows (Vol. VI, p. 664, lines 10-15):

> "In devices made in accordance with my invention gas ionization is either entirely absent or is negligible and a discharge takes place which is distinct in its characteristics from the described discharge taking place in an ionized gas."

The specification goes on to say (lines 24-27):

> "As distinguished from discharges in the presence of positive ionization, the pure electron discharge is characterized by regularity and reproducibility with given conditions."

The definition which the Court adopted is, morover, the same definition which counsel for respondent advanced before the trial court (Vol. II, p. 951):

> "Mr. Davis: The invention as I look at it, if your Honor please, is a tube in which the relation of the parts, the geometry of the tube, the nature of the gas, the amount of the gas, are so coordinated that a pure electron discharge will flow above ionization voltages."

The petitioner's real complaint is that we were successful for the first time upon the reargument in explaining the invention in such a way that the Court understood it.

In the petition for reargument (Vol. III, p. 2014) we said:

> "In simple language, Langmuir's invention consisted in taking out the conductor which was in the Fleming valve and the DeForest audion and putting nothing in its place; he dispensed with what was regarded as an essential element in the operation of the tube and by doing so made a tube which worked infinitely better."

Petitioner says that this is an entirely new and different definition of the invention from anything which had previously been suggested. It is new only as a matter of phraseology; in substance it is exactly what we said at the trial and in a brief filed on the original argument before the Court of Appeals. In that brief (p. 10) we said:

> "In the purely electronic tube—Langmuir's tube—the current is carried across the space between the electrodes by a procession of 'electrons,' which are very small negative charges or units of elec-

tricity, 'substantially unaffected by positive ionization' of the gas, as Langmuir says in his patent. The action would take place exactly the same even in the wholly imaginary condition called 'a perfect vacuum.' It is a simple, clean, dependable phenomenon, uncomplicated by any gas action whatever.

"The old audion, as we have seen, was an ionic or gaseous tube; in that tube 'ionization' of the gas was a vital factor in the conduction of the current."

Again (p. 18) we said in the same brief:

"The fundamental difference between the two devices is that in Langmuir's tube there is no ionization which substantially affects the current, while in the audion ionization is a vital factor in the phenomenon of current conduction."

To say, as we did in the petition for reargument, that Langmuir's invention consisted in taking out the conductor which was in the DeForest audion and putting nothing in its place is simply a striking way of stating the same thing. In fact the petitioner, in describing the phenomenon of ionization, says that "the positive ions act like traffic police for the electrons" which suggests the same idea of a conductor.

Petitioner concedes on page 42 of its brief that if our definition is correct, **"patentability follows almost as a matter of course."** It contends, however, that the definition is not correct, in that the Fleming and DeForest devices did not have a conductor of gas.

This is the controlling question in the case. Before referring to the citations upon which the petitioner relies, let us see what Fleming and DeForest and other workers in the art said on the subject.

The contemporary theory regarding conduction in a hot-cathode tube.

For many years the art believed that electric current at any reasonable voltage would flow only through a metallic or liquid conductor. Then came Edison in 1884 with his great discovery of the "Edison effect," which was that somehow electric current would flow in a vacuum tube across a gap from a heated filament to a cold plate or anode. This was a startling discovery, because, at first thought, it appeared to be utterly inconsistent with the accepted belief that current would flow only through a conductor. But like all great discoveries it appeared simple enough when it was explained. The explanation was that there was enough gas in the tube to form a conductor, or, as it was sometimes described, that there was a "column of conducting gas" which served as a conductor to carry the current across the gap from the filament to the plate. In the 1914 edition of the Century Dictionary and Cyclopedia, the Edison effect is described as

> "a phenomenon of the vacuum of incandescent lamps, consisting of an electric glow near the ends of the filament, caused by a current flowing through the gases between the terminals, or from a third terminal and the negative leg of the filament."

Fleming merely utilized the Edison effect in a vacuum tube with its column of conducting gas for the detection of radio signals.

DeForest simply improved the Fleming valve by adding the grid.

Both the Fleming valve and the DeForest audion were gaseous tubes. While Fleming and DeForest and the art generally did not understand just what the action of the

gas was, they visualized it and spoke of it as a physical conductor, and regarded it as essential.

Fleming in his scientific paper delivered before the Royal Society in 1905, after describing the behavior of his valve, said (Vol. V, pp. 148-149):

> "the facts so exhibited are well-known characteristics of *gaseous conduction in rarefied gases.*"

citing J. J. Thomson's book "Conduction of Electricity Through Gases."

In 1908, in an article published in Cassier's Magazine, Fleming said:

> "The form of oscillation valves devised by the author depends on the unilateral *conductivity of a mass of rarefied gas* contained between an incandescent and a cold-conducting surface" (I. R. p. 1337).

In the 1910 edition of his book Fleming said:

> "In both Mr. Marconi's and the author's above-described method of employing the valve, we are utilizing the unilateral *conductivity of the ionized gas* which it possesses in virtue of the electrons discharged from the incandescent filament. On the other hand, we may employ this detector in another manner, depending on the fact that such ionized gas does not obey Ohm's law as a conductor" (I. R. p. 1343).

In his 1916 book Fleming continued to speak of the "ionized gas" in his valve as a "conductor" (I. R. p. 1345).

In a patent granted to DeForest in 1907 he describes the audion as

> "an evacuated vessel enclosing a sensitive *conducting gaseous medium* maintained in a condition of molecular activity" (I. R. p. 1496).

In discussing a paper which he read before the American Institute of Electrical Engineers in 1906, DeForest was asked whether the action of the audion depended upon the ionization of residual gases within the vacuum, or whether the vacuum was so perfect that the ions or electrons came from the electrodes themselves, to which his answer was (I. R. p. 1493):

> "I think it is due to the ionization of the residual gases; the gases still exist in the lamp, because the vacuum is only that which obtains in all incandescent lamps."

At the same meeting, when asked whether the residue of gas left in the exhausted envelope had anything to do with a certain "lag effect," DeForest said:

> "Well, of course, the gas has something to do with the phenomenon. *If the exhausting process is carried too far, the audion loses its sensitiveness. The gas particles, rather than the particles of the metal dust, are the carriers*" (I. R. p. 1496).

In his patent No. 1,201,273, issued on an application filed in 1915, DeForest explains the conductivity of the audion as due to the "ionizing of the gas in the evacuated vessel" and speaks of "the conductivity of the surrounding or interconnecting gas medium" (Vol. IV, p. 330, lines 40-43 and 96-98).

Gernsback, in a critical study of the operation of the audion, said that

> "the operating principle is the shattering of a column of conducting gas by a received electrical impulse" (I. R. p. 1505).

And the art was right; the gas was not merely the thing that made the audion "tricky" and irreproducible; the gas

was the thing that made the audion work. If you got rid of the gas, you made the audion inoperative; it might be an obvious way to get rid of the trickiness, but in the view of the art it would have been very much like cutting out a man's tongue to cure him of stuttering.

We have quoted DeForest's statement that if the exhausting process was carried too far the audion lost its sensitiveness; experience confirmed this statement. Sometmes an audion would "clean up" in operation; that is to say, the vacuum would become higher and the tube would become what was known as "hard." A hard audion was not a good audion, and it was common practice to resort to the expedient of heating the tube in order to liberate gas from the walls, and so to increase the gas pressure (reduce the vacuum) enough to "soften" it to that value at which the audion would function. When an audion got so hard that it would not respond to such treatment, it was discarded as useless; as the defendant said in its 1919 circular:

> "after continued use the tube would get 'hard' and require more 'B' battery until it reached such a state as to be inoperative" (*supra*, p. 4).

If anyone went to the art for an explanation of why this was so, he would have been told that it was because there was not enough gas in the tube to form a conductor, and that without such conductor no current would flow.

For instance, in the United States patent of Von Lieben, Reisz and Strauss, applied for as late as June, 1912, for a form of hot-cathode tube seriously considered by the Telephone Company for telephone relay uses in early 1913 (Vol. I, pp. 514-516; Petitioner's Brief, p. 70), it is said (I. R. p. 1440):

> "It is a well known fact that exhausted discharge tubes can be worked only for a comparatively short time, as the discharge ceases after a short period if it is continuously maintained for some time. * * *"

The patentees go on to state that the discharge ceases because the resistance of the tube increases as the gas cleans up.

And this was the common view of the art; for example, Dr. W. R. Whitney, director of the Research Laboratory of the General Electric Company, said in a paper read before the American Institute of Electrical Engineers in June, 1912, shortly before Langmuir's invention was made:

> *"In connection with this work of Fleming's, we have studied the effect of the condition of vacuum on the current, and also found that the presence of gas is necessary for this negative discharge"* (I. R. p. 1514).

Langmuir described at I. R. page 1557 some of the work which led to this conclusion.

Arnold in his patent application stated (I. R. p. 498):

> "It has been commonly supposed that the electrons thus emitted *must be utilized to ionize the residual gas in the vacuum tube in order that the device might operate efficiently.*"

And in his testimony he confirmed this statement (I. R. p. 499).

When Langmuir discussed his invention with the distinguished physicist Wien and told him that he had succeeded in obtaining a pure electron discharge in the very highest vacuum, Wien exclaimed "Dass kann nicht sein"

(That can't be so) (Vol. III, p. 1941). The great physicist Rutherford was of the same opinion in 1914 (I. R. p. 1513). Prof. Robert Pohl of Germany wrote Langmuir in 1914, "congratulating me on the work that I had published in the *Physikalische Zeitschrift* and pointing out how the paper had changed his views on this question of electron emission in high vacuum and was likely to change the views of a great many other German scientists" (I. R. p. 1929).

Even after Langmuir's invention had been published, DeForest insisted that Langmuir was working on the wrong track, or as he put it in the discussion of Langmuir's paper read before the Radio Institute in 1915:

> "I believe, however, that Dr. Langmuir has, by working into these extremely high vacua and the high potentials necessitated thereby, *pursued the less promising of two paths of research*" (Pl. Ex. 104, physical, p. 292).

The evidence of gas conduction in the Fleming valve and DeForest audion.

The art did not know just how the gas acted as a conductor, and it was wrong in believing that without such a conductor no current could flow. It was Langmuir who taught the world these things, and his explanation is now universally accepted. But the art was right in believing that there was a gaseous conductor in the audion, and that the useful flow of current depended upon gaseous conduction.

If the Court should entertain any doubt on this point we hope it will read Langmuir's deposition in the Interference Record, particularly commencing at page 1599, where he discusses the difference between tubes of the patent and tubes of the prior art, and also his testimony

beginning at Vol. II, page 1236, where he discusses the same subject with particular reference to the DeForest audion and the Fleming valve. The whole matter is too complex to be covered in a single sentence, but for the convenience of the Court we quote portions of Langmuir's testimony.

At I. R. page 1599, he says:

> "Thermionic devices utilizing a pure electron discharge are characterized by constancy and reproducibility in their action, and by a long, useful life and by the fact that large amounts of power can be controlled by them. In each of these respects they differ radically from the devices of the prior art such as the Fleming valve, the audion, the Von Lieben tube, the Wehnelt rectifier and the Lilienfeld X-ray tube *which all used and depended upon ionization.*"

At Vol. II, page 1242, he says:

> "In other words, in the devices of the old art, in the DeForest audion, the pressure was continually changing. It sometimes increased and it sometimes decreased. * * *
>
> "These things were going on in the most erratic and ungovernable way in the old devices and that is true of all devices that are poorly exhausted.
>
> "If there is a pressure of gas such that the ionization produced by it modifies the space charge, partly eliminates the space charge, and therefore allows more current to flow than would otherwise flow, then any change in that gas pressure will cause a change in the ionization and space charge will be eliminated to a different degree and there will be a resulting change of current."

At I. R. page 1325, Langmuir, referring to the Fleming valve, testified:

> "his currents were totally different from what they would have been in the absence of ionization."

Defendant's expert Chaffee testified to the same effect (Vol. I, p. 262, XQ431, *infra*, p. 43).

Defendant's witness Arnold, in his patent application, stated (I. R. p. 498):

> "The DeForest audion, according to the printed description thereof by its inventor (see Proc. A. I. E. E., Vol. 25, p. 735, 1906), and according to the patents therefor (U. S. Patents Nos. 841,387 and 879,532) depends upon the principle of gas ionization. The same is also true of the Fleming detector (See statement contained in U. S. Patent No. 954,619)."

We have already referred to the DeForest Bulletin of 1919 which refers to the "old style" "ionic or gaseous" tubes. Another bulletin published by the DeForest Company in 1915 shows beyond question that the audions which the defendant was making and selling at that time were gaseous tubes. The bulletin states (Vol. IV, p. 137):

> "If too much battery 'B' voltage is applied in any Audion Detector, a blue glow will appear in the bulb or may be seen around the edges of the plate or wing, and a roaring sound will generally be heard in the telephone receivers."

In the same bulletin we are instructed regarding the proper adjustment of the B voltage (Vol. IV, p. 140):

> "Now start the switch B at the lowest point 12 and turn to the right until a blue discharge occurs in the Audion bulb, or a hissing noise occurs in receivers. Bring the switch back one point at once, as the blue discharge, if prolonged, is detrimental to the bulb."

There was no difference in this respect between the audion detector and the audion amplifier; for the same bulletin says (Vol. IV, p. 142) that the directions for operating an amplifier are the same as for a detector (see also p. 36, *infra*).

Here we see the same critical adjustment of the B voltage to the point just below that at which blue glow occurred which the defendant in its 1919 Bulletin says was necessary with old style gaseous tubes.

Langmuir explained the reason for this critical adjustment (I. R. p. 2007):

> "This careful adjustment to an optimum value of the voltage is just what was common practice among those who used the audion for receiving radio signals. The best amplifying action is obtained just before the strongest ionization effects are obtained. This usually occurs a little below the voltage at which appreciable blue glow occurs, but the sharp rise in the current proves that space charge is being greatly modified by the presence of positive ionization."

There can be no doubt therefore that both the Fleming valve and the DeForest audion, when operating at voltages above the ionization voltage, depended upon ionization; the gas acted as a conductor of the current.

Langmuir's testimony cited by petitioner.

The petitioner quotes Langmuir as repudiating our position that the Fleming valve and the DeForest audion depended upon gaseous conduction. The argument, which confused Judge WOOLLEY, is based upon an incomplete quotation from Langmuir's testimony, the effect of which is entirely reversed when read in connection with the context.

In the original specification Langmuir had said, describing the action in the old-style gassy tubes, "the positive ions take part in the conduction of current, giving at first erratic readings on measuring instruments connected in circuit."

The statement was subsequently cancelled from the specification and the following substituted:

> "Under these circumstances the phenomena of *conduction* across the tubes are the result of the action and interaction of the electrons and the ions. These phenomena are in general erratic and non-reproducible."

In cross examination, Langmuir was asked whether the original statement would have been true if it meant that "the positive ions take part in the conduction of current *by acting as conductors of current.*" His answer was in effect that the statement would not be scientifically accurate. From this petitioner seeks to draw the conclusion that Langmuir repudiated the theory of gaseous conduction in prior-art tubes, but if petitioner had quoted the whole of Langmuir's statement it would be apparent that such was not the case, because Langmuir had just said (I. R. p. 1774, XQ67):

> "The sentence 'The positive ions take part in the conduction of current' is a perfectly natural way of expressing the fact that the presence of positive ions greatly increases the current under certain conditions. *In fact, since the current is increased as the result of the presence of positive ions,* it is absolutely true that the positive ions *'take part' in the conduction of current.* It does not necessarily follow from this statement that the current is carried by the positive ions. The statement is simply a rather loose way of stating that the current is dependent on the positive ionization."

It is evident from this that the change was merely one of phraseology and not of substance, and that Langmuir never repudiated the theory of gas conduction in prior art tubes.

This is further confirmed by the following statement which appears in the original specification as well as in the patent:

> "The phenomena above described as being characteristic of devices involving gas ionization are taken advantage of in an incandescent cathode device known as the 'Audion.' This device has been used as a receiver for radio-telegraphy and *depends in its operation upon the rapid change of the discharge current when gas ionization begins*" (Vol. VI, p. 63).

Petitioner's references to prior art on conduction of electricity by gas.

Petitioner says there is no testimony in the record that either Fleming or DeForest ever *purposely* left a *definite* residue of gas in their tubes for the purpose of conducting the current or of making them operate.

Fleming paid no attention to his vacuum; he was satisfied with the ordinary incandescent lamp vacuum of his time. DeForest definitely said that the action of the audion was due to the ionization of the residual gas, and that *if the exhausting process is carried too far, the audion loses its sensitiveness* (*supra*, p. 25).

What DeForest knew was that if the vacuum was so poor that a tube blue glowed at 15 or 20 volts, it was no good for his purposes because it gave him no reasonable range of operation above ionization and below saturation voltages. He also knew that if the vacuum was too good the tube was inoperable. What he wanted,

therefore, and what he used, was a tube exhausted to the optimum pressure which would give him a maximum effect of ionization with a reasonable range of operation.

Fleming was just as vague about the pressure in his valves. While he speaks of the "highest attainable vacuum," we know, and the petitioner's witnesses admit, that his valve was a gassy tube and that his current at voltages above ionization operated by gaseous conduction (*infra*, p. 43).

The petitioner quotes Waterman's testimony in the case of *Marconi* v. *DeForest*, 236 Fed. 942. It does not, however, quote the most significant part of his testimony, which is at Vol. III, page 1488:

> "A. Well, in order that the electrons may have undisturbed passage across, it is necessary that there should not be too many gas molecules in the way. I am going in a minute to read what Fleming had to say about that, about the significance of the vacuum. If the vacuum is so high that the electron streams across from the filament to the plate are not seriously interfered with then the vacuum is sufficiently good for the purpose. But if there is very much gas present—
>
> "Q. What do you mean by 'very much'?
>
> "A. *I mean if a vacuum is not equal to a reasonably good incandescent lamp vacuum*, for example, then the bulb gets freaky."

Petitioner's counsel think they find some inconsistency between Hogan's testimony given in the *Hewitt* case in the year 1919 and his testimony in this case. Hogan himself saw no such inconsistency. Maybe Hogan was wrong in the *Hewitt* case, but no witness says he is wrong in this case. The significance in the reference, however, lies not in what Hogan or any other witness may have said, but in what the Court decided, namely, that the Tele-

phone Company's tubes, which were admittedly the tubes of the Langmuir patent here in suit, *depended upon a principle and mode of operation clearly different* from that of the Hewitt tube, which was a gassy tube, in that the Telephone Company's tubes operated independently of ionization whereas the Hewitt tube depended upon ionization for its action (272 Fed. 194 and 392).

It is a novel proposition that a case should be decided on the testimony of witnesses given in some other case, directed to a different state of facts, but if petitioner wishes to urge such a proposition, it ought, in fairness to the Court, to call attention to the testimony of its own expert, Millikan, who, testifying in the same case for the Telephone Company, said, and in so saying was sustained by the Court, that the devices used by the Telephone Company worked *"on an entirely different principle"* (Vol. I, p. 118), which he explained was due to the fact that they *were "evacuated to such a degree that the residuary gases play no part in the operation"* (p. 119), so that the current was governed by the space charge, unaffected by positive ionization (p. 115).

Here is a clear recognition by Millikan that the difference between Langmuir's tubes and the tubes of the prior art was a difference in principle and mode of operation.

Langmuir's references to Lilienfeld, which the petitioner has also quoted in connection with its first point, will be discussed in connection with our answer to that point (*infra*, p. 45).

The quotation from Lord KELVIN contains no suggestion that the Edison effect does not depend upon gas.

Von Beyer speaks of working in the highest possible vacuum, when in fact we know that when he lighted his filament the pressure was about 10 microns and that it was

> "necessary to renounce the study of the effect of different gases—because of the continuous evolution of gas from the wire and also because of the occlusion of gas which always occurs" (I. R. p. 2005).

Petitioner quotes Judge MAYER's opinion in the *Marconi-DeForest* case. In the same case Judge HOUGH, speaking for the Court of Appeals, said (243 Fed. 565):

> "The gaseous medium of the audion is nothing but the commercial vacuum of the ordinary electric light bulb—air being a gas, and the bulb containing some residual air, in other words defendant (DeForest) uses the same 'vacuous' vessel that Fleming does."

The petitioner says that the reference to gaseous tubes in the DeForest 1919 Bulletin can refer only to the detector tubes. But the Bulletin makes no distinction between detectors and amplifiers, and the uncontradicted evidence shows that the pressure was the same in both (Vol. III, p. 1620). Moreover, an earlier DeForest Bulletin issued in 1915 shows that there was no difference in this respect between detectors and amplifiers (*supra*, p. 30), and DeForest's fundamental paper on the audion amplifier, published in 1913, after Langmuir had made his invention, makes it clear that the audion amplifier was just as gassy as the audion detector (I. R. pp. 1497-1500).

In conclusion petitioner makes the amazing suggestion that the new purely electronic tube described in the 1919 bulletin is nothing more than the old gaseous audion which the bulletin tells us was very unstable in operation and had the decided disadvantage that, after continued use, the tube would become hard, requiring more B-battery voltage, until it reached such a state as to be inoperative.

The petitioner says that it is fantastic for us to contend that if the vacuum in a DeForest tube was made better by him, or became better in use, the tube was no longer operative, but if it was made better by Langmuir the usefulness was greatly increased.

This is not our contention. When the vacuum in a DeForest audion became better with use, the audion became useless. Langmuir's invention is not a useless, but an immensely useful, thing.

A hard audion was useless because it was still a gaseous tube, designed for use as such. The only way to make it operate was to increase the gas pressure to the value at which the gas would act as a conductor; it was common practice to do this by heating the tube so as to liberate more gas and increase the density. This is exactly what the DeForest bulletin recommends (Vol. IV, p. 137). When this expedient failed the audion was discarded.

The Langmuir tube is a useful tube because its operation is not dependent upon gas. Langmuir dispensed with the gaseous conductor upon which the useful operation of the DeForest audion depended, and by doing so made a tube which worked infinitely better.

POINT II.

The invention is not merely a DeForest audion capable of operating at higher voltages. The essential difference is that at any voltage the tubes of the patent are stable and reproducible as contrasted with the audion which was always erratic and non-reproducible. The invention is not a vacuum or degree of vacuum; the vacuum is important only as one of the elements of a combination which produces a new, useful and unexpected result. Such a tube was new in the art, and required new and different vacuum technique to produce it. The old tubes operated on the old principle of ionic or gaseous conduction; the new tubes operate on the new principle of pure electron discharge. (Petitioner's first point.)

The petitioner asserts that the invention is nothing more than a Fleming valve or DeForest audion capable of operating at higher voltages and with more power. It says:

> "The advantage of improving the vacuum lies not in getting a *new* kind of performance, but in getting *more of the same kind.*"

If this were the invention we think the patent would never have gotten out of the Patent Office. But it is not the invention, and in another part of the brief petitioner's counsel stoutly contend it is not the invention. At page 85, in an effort to prove that Langmuir did not reduce the invention to practice in August, 1912, they say that Langmuir's August tube, which was operated at 200 and 250 volts, did not embody the invention because the discharge was "still greatly affected by ionization." Yet in the next breath (p. 98) they ask the Court to find that

simply because some DeForest audions may have operated at 54 or 67½ volts they must have operated by pure electron discharge substantially unaffected by ionization.

The prior art devices.

The petitioner refers to three prior art devices which it claims embody the same structure and principle of operation as the tubes of the patent. They are: the DeForest audion, the Fleming valve and the tube described in Lilienfeld's German paper published in 1910.

The DeForest audion.

By an ingenious play on words the petitioner makes a plausible argument that any tube which amplifies at voltages above the ionization voltage is a tube of the patent, from which it asks the Court to conclude that because the old style gaseous DeForest audions amplified at voltages above ionization, they must have operated by pure electron discharge. The introduction to this amazing argument is subtle. At page 27 of the brief, after having enumerated the characteristics of a pure electron discharge as stated in the original specification, the petitioner says:

> "All these criteria are summed up in the simple statement that there must be absence of 'harmful ionization' as this term is employed by respondent's witness, Hogan."

Petitioner then ignores what Hogan said he meant by "harmful ionization" and substitutes a definition better suited to the argument, which is that harmful ionization is ionization such as would make the tube inoperable, and from this definition petitioner argues that any tube which amplifies is a tube of the patent.

The argument, of course, would apply equally well to a detector. The audion detectors, as well as amplifiers, were always operated above ionization voltages (Van der Bijl, I. R. p. 99), so that the petitioner's argument logically leads to the conclusion that a detector, which was admittedly a gas device (Petitioner's Brief, p. 95), was nonethe-less a pure electron tube of the patent.

The trouble with the argument is that neither the patent nor Hogan gives this definition of "harmful ionization." Hogan explained very clearly what he meant by harmful ionization (Vol. I, p. 96, XQ29):

> "Harmful ionization would be that which would interfere with the operation of the device in such a way as to produce a low power limit or affect its uniformity of operation, or otherwise produce difficulties."

Therefore, if harmful ionization is to be used as the test it must be used in the sense in which Hogan used it. The test is not whether a tube will amplify, but whether it will amplify uniformly and reproducibly, and this is the test which petitioner's own experts give as the most satisfactory test to distinguish between a tube operating by pure electron discharge and a tube operating by gas conduction. Petitioner's expert, Millikan, said (I. R. p. 840):

> "Hence, it is unquestionably true, as I stated in my original testimony that, barring the 3-electrode test, the *showing of an ideal and reproducible characteristic is the most simple and practical test we have for a pure electron discharge.*"

Petitioner's expert, Van der Bijl, said (I. R. p. 778):

> "I look upon a discharge as a pure electron discharge *if the characteristic is sufficiently steady and reproducible* to enable us to use the device to per-

form satisfactorily any one or more of the functions for which it is designed."

It is exactly the test of harmful ionization which petitioner points out in another part of its brief (p. 9) where it says:

> "For reasons which need not be here stated, however, the gas content in a tube, and so the amount of ionization, varies with temperature, the life of the tube and other things, so *that erratic and undesirable operation may result.*"

So also from the standpoint of practical use, ionization is harmful if it makes the tube erratic and irreproducible. The audions which DeForest furnished to the Telephone Company and which petitioner now says operated without "harmful ionization" were nevertheless "of practically no value in the telephone plant" (Vol. II, p. 721), because they were critical and erratic. As petitioner's witness Jewett, one of the Telephone Company's engineers, said (I. R. p. 2218):

> "I saw, however, that if the remarkable action which it evinced with small alternating current input on the grid and *with the plate battery voltage carefully adjusted to its optimum value* could be obtained with an input alternating current of the magnitude which must be provided for in telephone operating conditions, and if this operation could be obtained reliably, *that is, if the erratic behavior of the DeForest audion could be eliminated,* then it might be an instrument of considerable importance for telephone service."

The careful adjustment of the plate battery voltage to its optimum value and the erratic behavior of the audion to which Jewett refers establish beyond question that these audions depended for their amplification

upon the effects of ionization, just as Langmuir has explained (*supra*, pp. 29 and 31).

The critical adjustment of the B-battery voltage in the audion was not to get a pure electron discharge, but to get a discharge in which ionization played the maximum useful part.

Langmuir regards as "harmful" the ionization which DeForest regarded as essential.

So from the point of view of the user of a Langmuir tube, the ionization which DeForest thought was helpful and necessary is "harmful"; the modern user of tubes demands a tube which does not require constant and critical adjustment. So just as the expressions "high vacuum" and "highest possible vacuum" mean one thing to a steam engineer and mean another thing to Fleming and mean an entirely different thing to Langmuir and the modern art, so the expression "harmful ionization" means one thing when used from DeForest's point of view and another thing when used from the point of view of the Langmuir patent.

The difference between a Langmuir tube and a DeForest audion is not merely a matter of the voltage at which the two tubes will operate. The audion was intended to operate at some voltage critically adjusted for each particular tube and for the varying condition of the same tube, somewhere between 20 and 50 volts. The DeForest Company recommended a variable battery of from 30 to 36 cells (normally about 45 to 54 volts). With the B-battery voltage carefully adjusted to the optimum value, and with absurdly small currents, the audion would amplify. At the same voltage a Langmuir tube would amplify, but the Langmuir tube would operate the same hour after hour, and day after day; the audion would not operate the same very long and no two audions would operate the same at

any one time. The reason is that the current in a Langmuir tube, being independent of any action of the gas, is steady and reproducible. The current in a DeForest audion, being dependent upon the varying conductivity of the gas, is erratic and irreproducible, requiring constant adjustment of the B-battery voltage to compensate for the varying conductivity of the gas. The essential difference is that the two tubes, operating under identically the same conditions, depend upon entirely different principles of operation; the audion on the principle of gas conduction, the Langmuir tube on the principle of pure electron discharge.

The Fleming valve.

Fleming, the inventor of the Fleming valve, described his invention in 1905 in a scientific paper before the Royal Society (Vol. V, p. 143). In this paper he described the characteristic operation of his valve, illustrating it by curves showing the current readings at different voltages. The defendant's expert, Chaffee, testified that he had examined these curves; when asked what they indicated he said (Vol. I, p. 262):

> "A. They indicate certainly the presence of gas.
> "XQ432. They are bad curves from the standpoint that we are discussing now?
> "A. Yes, they certainly indicate presence of positive ionization."

Fleming's subsequent publications up to and after the date of publication of Langmuir's work show that he regarded his valve as operating by gaseous conduction (I. R. pp. 1335-1347).

Petitioner does not rely upon this scientific article; it prefers to rest its case, so far as Fleming is concerned, on an article which Fleming published at about the same

time in a very "popular" English journal (I. R. p. 1351), copied in the "Scientific American," in which he uses the terms "very peffect vacuum," and "highest attainable vacuum," and says that a vacuum is high "when it is reduced to one hundred-millionth of an atmosphere." Fleming was simply indulging in striking hyperbole permissible in a non-scientific article. In those days nobody knew how to measure a vacuum of a hundred-millionth of an atmosphere (Vol. I, pp. 208-209). What Fleming was really talking about is demonstrated by another statement in the same article, which the petitioner does not quote (Vol. V, p. 174):

> "when the vacuum is very high (that is, if the residual gas pressure is something less than one ten-millionth of an atmosphere) the phenomena becomes simplified. We then observe the well-known effects of the Crookes or Roentgen tube. The electrons in the negative electrodes are projected from it owing to the great electric force with very high velocities; and as their path is not sensibly disturbed by the sparsely distributed molecules of the remanent gas, we have all the phosphorescent and other remarkable effects due to the bombardment of these electrodes, and their impact against the glass walls of the vessel or objects placed in the tube. This state makes itself evident by apple-green phosphorescence of the glass vessel."

So the vacuum to which Fleming referred was the vacuum of the old Roentgen X-ray tube, which had a cold cathode and in which the conduction was caused and conditioned by the gas ionization, and which, like the audion, ceased to operate when the vacuum became too high (Vol. II, pp. 1175-1178). The actual gas pressures in these old X-ray tubes were substantially the same as those in the De Forest audion and in the carbon-filament

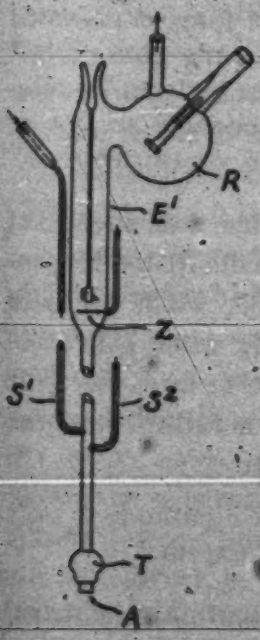
incandescent lamp of those days. This was also the pressure in the Fleming valve (Vol. III, pp. 1574, 1660, 1661), as Fleming himself repeatedly said (I. R. p. 1309) and as the Court of Appeals of the Second Circuit held in *Marconi* v. *DeForest*, 243 Fed. 560.

This Fleming matter is discussed at Vol. III, pages 1676-1679 and at I. R. pages 1307-1362.

The Lilienfeld experimental tube.

Petitioner quotes with reference to Lilienfeld a few disconnected sentences from Langmuir's deposition. Langmuir fully discussed Lilienfeld's work and showed what it was that Lilienfeld did, at I. R. pages 1364-1407; see also Hogan, Vol. III, pages 1697-1709.

The Lilienfeld paper described certain laboratory experiments performed with a complicated and utterly useless tube which is here illustrated.



During the experiments the tube was kept immersed in liquid air and was never sealed off from the pump. The current was carried by an action entirely different from that of a radio tube, and no possible utility for such a device has been suggested by any one. The only use to which it was ever put was to demonstrate to Lilienfeld's satisfaction a theory of physics which all the experts ridicule (Chaffee, Vol. I, p. 338; Hogan, Vol. III, p. 1702; Millikan, I. R. p. 155).

Lilienfeld's paper taught the world nothing useful. It is true, as Langmuir frankly said, that Lilienfeld took precautions to get

the highest vacuum that he knew how. But the conduction in the Lilienfeld tube was not Langmuir's conduction; his tube "operated on a totally different principle" (I. R. p. 1784); in Lilienfeld's tube no electrons passed directly from cathode to anode; they progressed through the tube by a series of jerky steps by a mechanism known as "secondary electron emission" (I. R. pp. 1066-1071). This caused the energy of the discharge to be delivered to the walls of the tube (Vol. V, p. 368) rather than to the anode, which protected the anode from bombardment (I. R. pp. 1380-1381). Langmuir has no hesitation in stating that Lilienfeld's vacuum was good enough to prevent positive ionization from affecting *such* a discharge, but nobody has suggested that such a discharge has any practical use (I. R. p. 1398). As the Law Examiner said (Op. p. 13):

> "The Lilienfeld device with its long, constricted tube is obviously impractical for any commercial purpose. The walls would tend to melt under electron bombardment and would become so hot as to furnish vapors under their own vapor pressure."

Lilienfeld's arrangement of electrodes was such that it was impossible to bombard them sufficiently to produce a Langmuir tube (I. R. pp. 1433, 1403; see also Vol. III, p. 1531), as appeared strikingly when Lilienfeld tried to put his theories to practical use in an X-ray tube with a hot filament; the attempt was a failure because, as Lilienfeld himself said (I. R. p. 1400):

> "The drop of potential of such a cathode is only a few volts even in an extreme vacuum."

This means that he was unable to maintain sufficient vacuum to enable him to operate an X-ray tube with a hot cathode (I. R. p. 1400). He contented himself with

a form of X-ray tube which admittedly works because of gas ionization and is inoperable without gas (Vol. I, p. 280).

The alleged conformity of the tube of Lilienfeld's 1910 paper to certain tests useful for ascertaining the presence of a pure electron discharge in a practical tube is without significance; for example, the fact that Lilienfeld's "secondary emission" discharge was independent of filament temperature under certain conditions simply means that the current under those conditions was determined by the secondary emission phenomena (Vol. III, p. 1725) and constitutes no proof that it would have been determined by space charge in the absence of the secondary emission. Lilienfeld himself repeatedly said that he had no space charge in his tube (Vol. I, pp. 331-334; Vol. V, pp. 476 and 395).

There is no indication that space charge actually limited his currents (Vol. III, p. 1706). The constancy of the current was actually due to an enormous electrical resistance in series with the tube (Vol. III, p. 1705).

These matters are fully discussed at Vol. III, pages 1697-1709, 1724, and I. R. pages 1779, 1364-1407.

It seems absurd to suggest that the claims of a patent on an invention which has done what Langmuir's invention has done must contain limitations to distinguish them from any such useless toys as that which Lilienfeld describes, but it is impossible to find in Lilienfeld's tube on any theory a discharge "substantially unaffected by * * * secondary electron emission from the walls of the tube" (Claim 1); or "tube walls" "fashioned or shaped to permit the direct passage of a useful proportion of said electrons from cathode to anode" (Claim 2); or "the energy of the discharge delivered mainly at an electrode or electrodes" (Claim 25), &c.

The vacuum of the patent.

The petitioner says that the invention cannot be the degree of vacuum. We agree with this statement; it is exactly what the patent says.

As Langmuir said (Vol. 2, p. 1240):

> "The pressure does not make any difference in a tube, if the tube has good characteristics, is reproducible and stays reproducible during its life. No one would object to the tube because it had ten microns of gas in it, that would be the last thing to think of. But if it has ten microns of gas in it and that gas changes and the change of that gas causes the characteristics to change in an irregular way, in a non-reproducible way, then the gas pressure becomes important."

The invention is not a vacuum, or even a degree of vacuum; the vacuum is important only as one of the elements which in proper combination produce a desired result.

High vacuum in prior art.

The petitioner quotes several references in an effort to show that the methods necessary to obtain the vacuum of a Langmuir tube were old and well known. They are: Dwyer, Soddy, Doane and Bessel-Hagen.

The *Dwyer* patent covers an old style carbon filament incandescent lamp with the vacuum of the DeForest audion. It, of course, discloses nothing about getting the gas out of an anode or plate, which was the big problem. Defendant's expert Chaffee admits at Vol. I, pages 231-232, that this patent does not tell us how to make the Langmuir tube.

The *Soddy* patent covers a vacuum pump. This patent was cited as a reference against the second, third and fourth Langmuir patents which are not involved in this appeal, and it was expressly stated by counsel for petitioner that it was not cited against the first patent which is the only patent involved in this appeal (Vol. I, p. 346). Another Soddy reference which was offered by the petitioner but which is not cited in the brief (Defendant's Exhibit No. 18) discloses an experiment by which Soddy proved to his own satisfaction that when a hot cathode tube was thoroughly exhausted no current at all would pass through it (Vol. III, p. 1580).

The *Doane* article discloses nothing more than the old art carbon filament incandescent lamp exhaustion technique.

The *Bessel-Hagen* article described some experiments made with a tube in which the gas pressure increased the moment the current passed through the tube to a value considerably higher than that in the DeForest audion (Vol. III, pp. 1669 and 1670; Vol. I, p. 342). In the same article it is said (Vol. I, p. 342):

> "The electric current requires the ponderable gas particles as carriers, in order to cross from one electrode to the other."

None of these references discloses a pure electron discharge tube and none of them discloses the precautions necessary to produce a vacuum maintainable during operation in a hot cathode tube necessary if the device is to operate by pure electron discharge. We call particular attention to Langmuir's summary at I. R. pages 1489-91, of the difference between the old art which their citations typify, and the modern art which Langmuir created.

The petitioner quotes from the opinion of the Law Examiner but does not quote his conclusion. After considering all of the prior art references cited against the patent, including those referred to in the petitioner's brief and many others, the Law Examiner dismissed them all with the statement (Op. p. 12):

> "It is not seen that any of the remaining references made fully available to the public by proper disclosure the device now claimed in the issue as reformed, or that the proposed combinations of references, *with results not suggested by any one of them, were obvious. The fact seems incontrovertible that a substantial and valuable contribution to the art has been made and that, within the limits explicitly stated or necessarily implied in the claims retained, it is entitled to patent protection.*"

The novelty of pure electron discharge.

Petitioner criticizes us for referring to the pure electron discharge of Langmuir's tube as a "new type of discharge." Petitioner says it is not new, but petitioner's witness Richardson, in his book published in 1916 refers to the characteristic phenomenon of pure electron discharge as

> "an interesting effect which was discovered and explained by Langmuir" (Vol. IV, p. 339).

If, as petitioner contends, this thing which Langmuir did was nothing more than an obvious development of the art, why did it never occur to Fleming or DeForest, or others experienced in the art? Judge Morris said that the radio art was young, and there was no pressing need for such an improvement. But the art was not so young. Wireless telegraphy had been in practical use

since 1898 (138 Fed., p. 671). If the art was in its infancy, it was because it was being held back for the want of just such a device as Langmuir gave it. The art would be in its infancy today if it still depended upon the Fleming valve and the DeForest audion.

But whatever the fact may be about the radio art, certainly the telephone art was not satisfied with the inadequate devices upon which it then had to depend. Telephone engineers had visions of a transcontinental line. They realized, as defendant's witness Jewett put it, that to solve the problem "it was necessary to enlarge the art beyond anything that we knew" (Vol. I, p. 403) and that "the solution must be found in what was essentially an inertialess type of repeater, an amplifying device which involved the discharge of electricity through some sort of conducting medium that did not involve the moving of actual physical matter" (Vol. I, p. 404). They worked on this problem for a year and a half; the best solution which they found was a mercury arc repeater, which was never used.

DeForest was himself a telephone engineer. He appreciated that in the audion he had the ideal device if he could get rid of the trickiness and increase the power level to that which was required on an ordinary commercial line.

Here was a challenge to DeForest's knowledge and inventive ability. He was desperately in need of funds, and the success of his negotiations with the Telephone Company was of vital consequence (*Westinghouse* v. *DeForest*, 21 Fed. 2nd, at p. 925). If he had known how to overcome the limitations of the audion which obviously made it unsuitable as an element in a telephone repeater, his success would have been assured. *But he did not know how.* He risked the success of this vital demon-

stration upon a device which, as he recognized and admitted (Vol. I, pp. 497-8), and as Arnold testified, because of these limitations was "of practically no value in the telephone plant" (Vol. II, p. 721).

As the Supreme Court found in the *Telephone* case (126 U. S. 567), the "ordinary laws that govern human conduct" are more reliable guides to the truth than the testimony of a cloud of witnesses.

POINT III.

The audions relied upon to prove the defense of prior use were gaseous tubes operating by gas ionization. The fact that a tube may amplify at 40 volts or more is no indication that it is a pure electron discharge tube, and the uncontradicted evidence shows that the tubes in question were gaseous tubes. DeForest had no idea of a pure electron discharge; his own statements show that what he wanted was a gassy tube; a tube exhausted to a particular optimum gas pressure in order to utilize the maximum useful effect of ionization. (*Petitioner's fourth point.*)

The defense of prior use.

This defense is beautifully illustrative of the fundamental fallacy of the petitioner's whole argument on the question of patentability. As we shall see, it leads to the absurd conclusion that the old DeForest audion, which the petitioner in its 1919 bulletin tells us had "the decided disadvantage that after continued use the tube would get hard and require more B battery until it reached such a state as to be inoperative," was after all nothing more nor less than a Langmuir tube.

Facts as to detector and amplifier operation.

The petitioner's argument proceeds from certain premises which are either unsupported by any evidence or in contradiction of the undisputed evidence.

The petitioner states that the ordinary DeForest audion detector was recognized as a gas device and as such had an ionization voltage of about 25 volts and that it was, therefore, customary to use the detector with an impressed voltage of approximately 22½ volts; in other words, that the detector was ordinarily used at voltages below ionization. The petitioner's own testimony is just the reverse. Van der Bijl testified (I. R. p. 99) that the audion was never operated below ionization and (I. R. p. 194) that the detector was commonly operated from 30 to 50 or 60 volts.

Petitioner also makes the statement that when voltage *very slightly* above ionization voltage (25 volts) was impressed upon the audion detector it would blue-glow. Here again the statement is not borne out by the evidence. The voltage at which a tube will blue-glow, as we have seen, depends upon the pressure. The DeForest Company recommended for an audion detector, as well as amplifier, a variable battery of some 30 to 36 cells (usually about 45 to 54 volts) and the instructions were to adjust the battery at the voltage just below that at which blue-glow occurred.

It is true, as petitioner says, that when blue-glow appears an amplifier becomes inoperative, but the same is true of a detector, and it is true, in either case, whether blue-glow appears at a voltage slightly above the ionization voltage or whether it appears at some substantially higher voltage. But the fact that a tube operates, whether as an amplifier or detector, without blue-glow, is no in-

dication that it is operating by pure electron discharge (*supra*, p. 11).

From these false premises the petitioner argues that because certain audions may have amplified at 54 or 67½ volts (as to which there is no proof) they must have operated by pure electron discharge.

The argument is the same as that which the petitioner advanced under its first point and is completely disposed of in our answer to that point (*supra*, pp. 38-42). The fallacy of the argument is further demonstrated by the facts that

(a) no witness has testified that the tubes upon which the petitioner relies to make out this defence were pure electron discharge tubes;

(b) the evidence in so far as it shows anything about the operation of these tubes shows clearly that they operated by gas ionization (*infra*, p. 56);

(c) both Langmuir (Vol. II, p. 1285) and Hogan (Vol. III, p. 1614) testified positively and without contradiction that the process of evacuation used for these tubes could not possibly have produced a vacuum sufficiently high to avoid substantial ionization or anything better than the vacuum of a DeForest detector;

(d) during the taking of depositions the petitioner had a tube exhausted by the same process for the purpose of offering it in evidence but it was never offered and respondent was never afforded an opportunity to test it (Vol. II, pp. 1042, 1060-1063).

DeForest's letter to the McCandless Company.

Petitioner refers to this letter as though it proved that DeForest appreciated the desirability of a vacuum such as to permit of a pure electron discharge.

If DeForest had any such appreciation it is surprising indeed that he was not called as a witness.

The fact, of course, is that the letter shows no such thing. All it shows is that DeForest was not satisfied with a tube which blue-glowed at 15 to 20 volts—quite naturally because such a tube would saturate at voltages lower than those at which it was intended to operate, either as a detector or amplifier. He wanted a better vacuum than that, certainly; but all he wanted or thought he could use was the vacuum of the audion detector, which normally operated from 30 to 50 or 60 volts, the same optimum gas pressure that he always wanted.

Langmuir's testimony.

Petitioner quotes Langmuir's testimony as proof that the maximum amplifying power of an amplifier tube containing gas is secured at approximately 27 volts and asks the Court to draw the conclusion that any tube which amplifies at any voltage above 27 volts must therefore be a Langmuir tube.

We ask the Court to read this testimony (Vol. III, p. 1427). What Langmuir did say was that a gassy tube amplified very well; that a *particular* tube amplified best at about 27 volts, and not nearly so well at 40 volts. Just because one tube amplified best at 27 volts and another at 54 or 67½ volts does not mean that one was substantially affected by ionization and the other was not. It means simply that the critical voltage was different, due to the difference in the gas pressure. This was typical of all prior art audions and one of the great objections which the petitioner pointed out in its 1919 circular. In each case the audion was operating above ionization voltages, and the amplification was due to ionization.

Tungsten cathodes.

Finally the petitioner resorts to the desperate argument that because Lamont and Hyde may have used tungsten filaments, they may have obtained by accident a sufficiently high vacuum to cause the tubes to operate without appreciable gas ionization. The supposed authority for this is Langmuir's statement that in a *tungsten incandescent lamp*, after continued use, the pressure was probably less than one-millionth of a millimeter of mercury. Langmuir completely disposes of this argument at I. R. page 1491, where he explains that in an audion, unless special precautions are used to free the anode from occluded gas "this gas continues to come off practically indefinitely, *so that the clean-up effect of the tungsten filament is not sufficient to maintain a low pressure*"—by which Langmuir meant the pressure of a pure electron discharge; not the pressure in a "hard" audion, which was something like five microns (*infra*, p. 57), which was the pressure of an ordinary carbon filament incandescent lamp.

What the evidence shows regarding the California tubes.

But we do not have to speculate about these tubes, because the evidence shows very definitely what they were. Petitioner's witness Hewlett, when asked about the audions which petitioner now says he operated at 67½ volts, said (Vol. 2, p. 1008):

> "The voltage depended upon the degree of exhaustion of the particular tube I had in use and I would say it ranged around about sixty volts, but I had a glass beaker with a thermometer and the tube in the oil of this beaker and by lighting a small alcohol lamp under this beaker I could somewhat control the amount of B-battery used for best results.

"Q17. What was the effect of heating the vacuum tube in the manner you describe?

"A. Heating the tube lowered the amount of B-battery used on the tube."

In a bulletin published by the DeForest Company in 1915 it states (Vol. 4, p. 137):

> "A hard bulb can be 'softened' by heating very carefully and evenly over a flame for a few minutes."

Referring to Hewlett's testimony, plaintiff's expert, Hogan, said (Vol. III, p. 1616):

> "That is exactly like the tube heating that was commonly used by radio operators in the early years of the audion. The heat applied to the glass walls results in disengaging gas within the tube and therefore increasing the gas pressure in the tube and reducing the voltage at which a blue glow can be had, and also the operating voltage of the tube. A blueglow at sixty to seventy-five volts shows in the ordinary audion construction with a gas pressure of something like four to six microns."

It is evident, therefore, that these tubes which petitioner now says were the identical device of the patent are the identical old-art gaseous audions which petitioner in its 1919 bulletin (*supra*, p. 4) tell us "had the decided disadvantage that after continued use the tube would get hard and require more B-battery until it reached such a state as to be inoperative."

In other words, according to petitioner, the Langmuir tube which, to use the language of Judge Morris, "because of its stability, reproducibility and power, has made possible radio broadcasting, modern radio reception, and

long distance telephony" is nothing more than the old hard audion which the art regarded as useless.

While we do not subscribe to petitioner's conclusion, we do submit that if Langmuir had done nothing more than to develop such a marvelous use for a device which was discarded as useless, he would be entitled to the credit of having made an important invention.

POINT IV.

The question of priority was decided by the Patent Office tribunals in favor of Langmuir in a contest between the respondent and the American Telephone and Telegraph Company, which has openly defended the present case on this issue. The case for the patent has been strengthened, not weakened, by the evidence in the present suit. Langmuir made the invention when he made and operated a pure electron discharge tube in August, 1912, more than two months before Arnold's alleged date of conception. Arnold's whole idea was to take a DeForest audion and by pumping a better vacuum to extend the range of operation to somewhat higher voltages without modifying the essential nature of that operation. This is not the invention. His conception and disclosure were inadequate in that they did not include any adequate idea of means. The inadequacy of his conception is evidenced by his inconsistent statements and by his inability to make good tubes until after Langmuir's invention was disclosed to the public. (*Petitioner's third point.*)

The Arnold defense.

Whether Dr. Arnold or Dr. Langmuir was the first inventor was the subject of a long interference proceeding

in the Patent Office, in which some two thousand pages of printed testimony were taken.

The Langmuir application had been filed on October 17, 1913. Two days later Langmuir presented and orally summarized a paper on his work before the American Physical Society in New York. Arnold was present and participated in the discussion (I. R. p. 1596). The paper was published in the December, 1913, issue of the Physical Review.

It is now claimed that in November, 1912, Arnold made the invention in question. If he did, he did nothing to assert that fact until November 2, 1915, although he had known for two years what Langmuir had accomplished and was taking the credit for.

When the Arnold application was filed his attorney asked for an interference with the Langmuir application. The interference was declared. Then Arnold moved to dissolve the interference for lack of patentability. He lost. When he and his assignee, the American Telephone & Telegraph Company, had thus failed to block the Langmuir application, they proceeded with the contest of priority. The Examiner of Interferences and the Board of Examiners in Chief awarded priority to Langmuir. The Assistant Commissioner reversed the Board. Then the case went to the Court of Appeals of the District of Columbia, which reversed the Assistant Commissioner and decided that Langmuir was the first inventor; the patent accordingly was issued to Langmuir.

In the present case the defense that Arnold was the first inventor was openly conducted by counsel for Arnold's assignee, the American Telephone & Telegraph Company, and they appear on the brief now filed as "of counsel as to Point III."

A proceeding under R. S. 4915 between the Telephone Company and General Electric Company is pending in the Southern District of New York, awaiting the outcome of this case.

Since Arnold and the American Telephone & Telegraph Company, parties to the interference proceeding, are thus openly conducting this defense in the present suit, and as the decision here will be practically conclusive in the 4915 case, it would seem that this is a case in which by analogy there should be applied the rule of *Morgan* v. *Daniels*, 153 U. S. 120, recently applied in *Victor* v. *Brunswick*, 273 U. S. 670, and in the *Feed-Back Cases*, 278 U. S. 562.

The critical dates.

Arnold claims to have conceived the invention on November 1, 1912, and to have reduced it to practice November 29, 1912, and at various subsequent dates. It is our position that Langmuir made the invention in August, 1912, and that, therefore, the Arnold defense has no standing. It is further our position that Arnold did not conceive the invention on November 1, 1912, or reduce it to practice on November 29, 1912, or at any time of the slightest importance in this controversy.

The Court of Appeals of the District of Columbia, following the Board of Examiners in Chief in the Patent Office, held that Langmuir conceived the invention in August, 1912, and reduced it to practice November 19, 1912, and that Arnold neither conceived nor reduced to practice at any time during the year 1912.

Langmuir's Work.

Prior to July, 1912.

Langmuir is a graduate of Columbia University, 1903, and Ph. D. of the University of Goettingen, 1906, and since then has been the recipient of many scientific honors and degrees throughout the world. He came to the General Electric laboratories in 1909. The first problem on which he worked led him to a study of gases in filaments. This was the beginning of a research which lasted many years. One of the fruits of that research was the present invention; another was the gas-filled lamp, the patent for which was sustained in *General Electric* v. *Nitra-Tungsten*, 261 Fed. 606, and other suits, and was referred to by this Court in *United States* v. *General Electric*, 272 U. S. 480.

This early work is summarized at Vol. II, pages 1075-1116. From that testimony it appears that in this work Langmuir accumulated a unique knowledge of vacuum conditions existing in devices carrying substantial electric currents and a unique technique in producing and maintaining vacua.

By 1911 he and an assistant had spent several months investigating thermionic currents in low gas pressures. He testified in the interference, I. R. page 1557, as to what was the general opinion in 1911:

> "In a general way, however, the results seemed to indicate that, if a perfect vacuum could have been obtained, the currents would have stopped entirely.
>
> "I think that practically all the men in the laboratory, who had thought much on the subject, agreed with Dr. Whitney that the evidence seemed pretty strong that, with the very high vacua ob-

tained in well made tungsten lamps, especially if they were run above their normal voltages, the thermionic currents were negligible and would have disappeared entirely if the traces of residual gas could have been eliminated."

But Langmuir was not satisfied; as he said at I. R. page 1557:

"My own attitude could best be described as an open mind."

The July and August, 1912 work.

Early in 1912 he began to take a more active interest in the subject. He discussed the matter with Coolidge, he was familiar with the work of others in the thermionic field. He set his assistant Sweetser to study the "clean-up" phenomenon, which was then not understood. Sweetser was working by Langmuir's side, and what he did was under Langmuir's constant supervision and intimate direction.

Langmuir appreciated that for his purposes it was necessary to have a tube in which no gas would be evolved from the electrodes or any other source during the operation. Accordingly, using all of the technique which he had accumulated, he produced a tube which from the point of design and preparation was different from anything ever made before. The elaborate processes through which this was accomplished are described by Langmuir (Vol. II, pp. 1116, 1120, 1122) and by Sweetser, I. R. pages 1704, 1705-1707.

After the tube was thus thoroughly freed of the occluded gas and thoroughly exhausted, Langmuir's procedure was to let a little nitrogen into it and, by passing a high voltage current from the cathode to the anode, to clean up this

nitrogen by a physical and chemical action which is explained by Langmuir (I. R. pp. 1561-2). Thus, he could observe how the tube acted while the gas pressure became lower and lower, as the nitrogen was automatically cleaned up by the action of the current.

Very careful records were made of what was done. These records, mostly in Sweetser's handwriting, are in evidence as Plaintiff's Exhibits 99 and 100 and are fully explained by Sweetser at I. R. pages 1704-1720 and by Langmuir at I. R. pages 1561-68.

The first run on the tube was made on August 20, 1912. The current between the cathode and anode was at 250 volts. The records show that as the pressure of gas diminished and approached five-tenths of a micron the current dropped from 18 to 15 milliamperes. At five-tenths of a micron the current suddenly dropped to 5 milliamperes and stayed there. This drop in current is described at Vol. II, page 1125:

> "That (the fall of current) is due to the clean-up phenomenon that was going on as a result of the electrical discharge taking place between those two terminals at a difference of potential of 250 volts. And then a very remarkable phenomenon took place in that the current dropped suddenly from 16 to 15 and then to 5, up to 15, down to 5, and then stayed at 5 milliamperes."

The next day, August 21st, a second run was made with a lower effective voltage, 200 volts, under which circumstances it was to be expected that the final current would be smaller. It was 3 milliamperes (Vol. II, p. 1127).

Langmuir testifies at Vol. II, page 1128:

> "*In my opinion, there cannot be the slightest doubt but that* the currents at these lower pressures

in this device at that time, were currents from 3 to 5 milliamperes with 200 to 250 volts, in which *the current was limited by space charge, and was not substantially affected by ionization of the gas.*"

In the interference proceeding Langmuir, testifying to his work of August 20-21, said (I. R. p. 1563):

"The foregoing results show clearly that when the pressure of 0.5 microns was reached an entirely different type of discharge began to take place. The results show that the 18 milliampere current was determined by the electron emission from the filament, the space charge effect having been eliminated by the presence of gas. This saturation current remained practically constant as the pressure was lowered, until at about 0.5 microns the number of positive ions present in the space became insufficient to neutralize the space charge. A slight further disappearance of gas caused the current to be limited by space charge, and the current thus fell from 18 to 5 milliamperes. As the pressure decreased still further to 0.34 microns, the space charge current underwent only an insignificant change (to 4.5 milliamperes), *showing that at these lower pressures the space charge was substantially unaffected by positive ionization.*"

On August 28th he repeated the first run of August 20th. As to this referring to Sweetser's records, he testified (Vol. II, p. 1129):

"Low pressures were again employed, and a little lower down on this page, beginning at 3.06 o'clock a run was started, again at a temperature of 2225 degrees, and the nitrogen cleaned up almost exactly as it did in this Run 1, which I have just been describing. Again the current which was obtained with 250 volts on the anode, and with the use of a milliammeter to measure the current,

changed from 5 to 17, and then suddenly to 5 milliamperes at almost exactly the same pressure that was recorded before. That is, the pressure at the first reading that gave 5 milliamperes, the pressure was 0.4 micron."

Langmuir next let in a little nitrogen, and again cleaned it up. Here again when the pressure diminished to five-tenths of a micron the current dropped from 17 to 5 milliamperes, exactly the same results as in run No. 1 of the previous week. As to this drop Langmuir testified (Vol. II, p. 1130):

> "*This is just another illustration of this same fact, that we had passed from the condition where there was* a space charge which was eliminated by *the presence of positive ions,* so that the current was limited by saturation, and suddenly, when the pressure reached below a certain point, the supply of ions was no longer sufficient to neutralize the space charge, *and the current became limited by space charge.*
>
> "Now, these pressures of 0.4 micron are a good deal higher than the pressures that were used or ordinarily exist in pure electron devices today; but they are pressures that can be duplicated at any time with a device of this kind at present and give pure electron discharge under these conditions.
>
> "The reason that the positive ions at this pressure of 0.4 micron play no part in the neutralizing of the space charge, is that the positive ions go to the walls of the tube."

This work is recorded in Sweetser's record sheets, Plaintiff's Exhibit No. 99 (physical). It began July 20th and was prosecuted continuously until September 13th.

The tube used in this work we submit was the tube of the patent, its construction and its evacuation were such

that it operated by pure electron discharge substantially unaffected by ionization.

In each of the runs, that of August 20th, that of August 21st, and that of August 28th, the tube behaved in the same way; thus it showed the practical characteristic of the tubes of the patent, namely, that the current is reproducible and not tricky.

Langmuir quite frankly admits that he did not then draw the conclusion that he had a pure electron discharge substantially unaffected by positive ionization. He had the tube, which he had carefully prepared, and he knew how he had prepared it, he knew how it acted and he kept the most elaborate records of that, but he did not then understand the theory of its action. Indeed he was puzzled. By the accepted theory of the time, in such a high vacuum there should have been no current at all. But there was current, and that current had not responded to changes in filament temperature in accordance with Richardson's formula. These discrepancies excited Langmuir's attention, so much so that he arranged to see Richardson in New York and talked the matter over with him for a whole afternoon on the campus of Columbia University, but Richardson had no explanation to offer.

Langmuir was then interrupted by some other work which he had previously begun. In November he resumed this work, determined to work out the theory of the action.

In November, 1912, Langmuir worked out the theory of the action of his tube.

Langmuir prepared three more tubes. The operation of these highly evacuated tubes on November 19, 1912, is fully described in the interference record, I. R. page 1571, *et seq.*, and in the testimony at Vol. II, page 1139, *et seq.*

Every step is carefully recorded in Langmuir's note book and every possible sort of data set down. On page 139 of his note book he summarized what he had done. The period during which the tube was cleaning itself he called "the first stage." Of the second stage, that is, after the gas had been eliminated, he wrote in the note book (I. R. p. 1575):

> "(6) The second stage is characterized by reproducibility, especially of the maximum current."

Referring to this entry he testified (Vol. II, p. 1151):

> "The maximum current referring to the current observed with the maximum filament temperatures, which is the current which is limited by space charge independently of ionization."

Thus, he calls attention to the important practical characteristic of the tubes of the patent, the reproducibility of the current, the absence of that trickiness that characterized the old tubes operating by gaseous conduction.

Under date of November 22nd he enters in his note book his "new theory of Edison current" (I. R. p. 1576). It is a clear statement of the effect of space charge, the factor which controls the action of the current when unaffected by positive ionization.

Langmuir immediately disclosed these results to his associates (I. R. p. 2123). He regarded them "of vital importance" (I. R. p. 1577) and instructed Sweetser to make another tube like that of August. The preparation and exhaust of this tube are elaborately described by Sweetser at I. R. pages 1712-1715.

On November 21, 1912, Langmuir began a series of experiments on this tube (Vol. II, p. 1163). On November 26, 1912, he operated it on alternating current, which cur-

rent it rectified, at voltages in excess of 480 and with substantial currents. It embodied the invention in every respect (Vol. II, pp. 1165-1166; I. R. pp. 1583, 1585, 1723, 1728).

The discharges were characterized by reproducibility and constancy (I. R. pp. 1725, 1583, 1584, 1587).

On November 30, 1912, Richardson visited the laboratory. Langmuir showed him his tubes in operation and showed him that when the tube was operating in the range below saturation the current did not follow Richardson's law, but was independent of the filament temperature. Richardson was surprised, because, as he said (I. R. p. 510):

> "At first sight this looked as though there was something the matter with my theory."

But when Langmuir went on to show that as the voltage was increased to the point of saturation the current increased to the proper value, Richardson was very much relieved, because, as he said (I. R. p. 510),

> "I was naturally very pleased with these experiments as they showed that the currents were not saturated; whence it followed that the true value of the emission was not given by the currents at high temperatures and the current limitation was not due to my theory's breaking down at high temperatures."

The "current limitation," of course, was due to space charge. And in his book published later Richardson speaks of this limitation of current by space charge as

> "an interesting effect which was discovered and explained by Langmuir" (Vol. IV, p. 339).

Richardson testifies that when he went away he carried with him one or two of Langmuir's tubes (I. R. p. 512).

On December 10, 1912, Langmuir discussed his invention with Coolidge and fully disclosed it to him, and suggested that the principle of a tube operating without ionization be applied to an X-ray tube, and Coolidge, profiting by this suggestion, developed his well known X-ray tube (*infra*, p. 84).

The next month, January, 1913, Langmuir not merely suggested but confidently told Alexanderson that his, Langmuir's, tube operating without ionization was just what Alexanderson needed for use in a radio receiving set, and made some tubes for him for that purpose. Thus the Langmuir tube in the Alexanderson circuit became the basis for most of the receiving sets on the market up to the present time.

Langmuir's invention was made in August, 1912.

The tube of August, 1912, was not accidently produced, it was carefully prepared by the most expert and ingenious methods and for the deliberate purpose of freeing it from gas. The currents which it produced were not accidently obtained; they were no freak phenomena; they were reproducible, and they were reproduced again on August 21st and again on August 28th and again and again in November. That these currents were reproducible is the common, practical test of the tube of the patent. The data of the performance of these tubes were daily recorded and the records are in evidence; the data prove that they were operated by pure electron discharge unaffected by ionization. Finally we have the unquestionable testimony of Langmuir himself, drawn from this data, that the August tube was the tube of the patent.

Langmuir's tube was thus perfected and operated in August, 1912, two months before Arnold had an idea on the subject. Since Langmuir perfected it in August, 1912, he invented it in August, 1912. Mr. Justice STORY in *Washburn v. Gould*, Fed. Cases 17, 214, declared:

> "Whoever first perfects a machine, is entitled to the patent and is the real inventor."

The modern exception to this doctrine for the benefit of the prior conceiver in the exercise of due diligence has no application here, for Arnold does not claim to have entered the field until November, 1912.

The petitioner's criticism of Langmuir's work.

The petitioner's main attack on Langmuir's work of August, 1912, is based on Langmuir's frank admission that he did not at that time know that he had "a pure electron discharge substantially unaffected by positive ionization."

It is not necessary that he should have known; it is elementary patent law that an inventor need not understand the theory of his invention.

Langmuir had, and knew that he had, a *tube* which was carrying substantial currents at substantial voltages (Vol. II, p. 1128). It had a hot cathode and a cold anode: it was a Fleming valve, of a new kind, *a kind that operated very steadily and reproducibly at high voltages.* It responded to all of the claims of the patent, except a few claims which are limited to the third electrode.

Whether or not Langmuir knew the theory of the action of the tube, he knew how he had made the tube, and he made other like tubes that worked the same way.

Petitioner's counsel say there can be no reduction to practice without precedent conception, and that there can

be no conception without "perception," that since Langmuir did not know the theory of how the tube operated he could not conceive the invention.

This psychology of the act of invention is of account when a man is trying to claim as his date of invention a date back of the time he perfected his machine; the American patent law lets him have the benefit of the antecedent date of conception provided there is disclosure and diligence in reducing to practice. But when, as here, the inventor is not trying to carry his date back of the time he perfected his machine there is no need to go into the question. Surely a man has invented his machine when he has deliberately built one which works; there may be dispute as to whether he invented it at some earlier date; there is no disputing the fact he has invented it when he builds it and it works.

The cases which the petitioner cites have no application. *Tilghman* v. *Proctor*, 102 U. S. 707, was a case in which an accidental effect, unappreciated and never followed up, was relied on to anticipate a subsequent patent for an important invention. *Pittsburgh* v. *Cowles*, 55 Fed. 301, was a case of the same kind. The rule, as stated in these decisions, was expressed by Judge TAFT in the latter case as follows:

> "Accidents of this character cannot be relied on as anticipations of a patented process * * * when the operator does not recognize the means by which the accidental result is accomplished and does not thereafter consciously and purposely adopt such means as a process for reaching the result."

But Langmuir's August tube was not an accidental effect, unappreciated and not followed up. Langmuir recognized the means by which he had accomplished the

result and thereafter consciously and purposely adopted the same means for producing other tubes with which he accomplished the same result. It was not in any sense an abandoned experiment. He followed up his work until he had worked out the theory of the operation of the tube and explained to the world for the first time how and why current flowed in such a tube.

The petitioner also attacks Langmuir's August work upon the ground that there is no evidence that Langmuir had any conception of the utility of such a tube.

Its utility was self-evident. A tube with a hot cathode and a cold anode was a known, useful rectifier for alternating currents disclosed as such by Fleming and by Wehnelt. Langmuir's tube was obviously a two-electrode rectifier having all the capabilities of the Fleming valve and the Wehnelt rectifier and also having the new property that it operated very steadily and reproducibly at high voltages. Langmuir proceeded to rectify alternating current with a similar tube in November of the same year.

Petitioner attempts to meet this conclusive demonstration by saying (p. 84 of its brief):

> "This is not true because it was recognized the rectifiers, like detectors, work better with considerable residual gas."

Petitioner says this in spite of the fact that one of the admittedly infringing tubes which it sells and which is here in evidence (Pl. Ex. No. 5) is a pure-electron-discharge two-electrode rectifier. For rectifying current at very low voltages gassy rectifiers are preferable (Vol. II, p. 1352), but Langmuir's pure-electron-discharge tube without a grid, used as a rectifier, and so described in his patent (p. 5, line 35), is a commercial device, used up to 100,000 volts at least (I. R. p. 1607) and was employed on

a large scale in airplanes during the great war at exactly the voltage which Langmuir used in August, 1912 (I. R. pp. 1189 and 1607).

In the *Feed Back* cases, DeForest was accorded a date of invention based upon an accidental result of certain experiments conducted by his assistant in August, 1912, although there was not a word of evidence in that case that DeForest then appreciated any utility for the thing on which he subsequently was granted a patent. In that case the Court of Appeals in the Third Circuit said (21 Fed. [2nd] 925, affirmed 278 U. S. 562):

> "Whether DeForest advanced toward the invention intelligently or stumbled upon it is a matter of no concern, for it was an invention none the less. The United States Government and three great industrial corporations claim it and all the world is using it. DeForest may have made the feed-back hook-up without any preceding notion of how it would work; an order of things, we surmise, not unusual in electrical inventions. *It did work. Whether DeForest or Van Etten at once knew its theory of operation and its capabilities is not important if they recognized the phenomena and were able, at will, to re-set the circuit and reproduce the result.*"

Langmuir's invention of August, 1912, could be, and was, reproduced at will thereafter.

Petitioner next says that the evidence taken at the trial in Court, and which was not before the Patent Office, shows that the discharge in Langmuir August tubes was not a pure electron discharge substantially unaffected by positive ionization. The reference is to the testimony of the defendant's expert Becker, who, while characterizing the discharge as a "new type of discharge" and admitting

that the current was limited by space charge (Vol. III, pp. 1792-1793), contended that certain experiments which he had made with an approximately duplicate tube showed that the space charge was not pure and that further reduction of the gas pressure would still further have reduced the current (Vol. III, p. 1799).

Langmuir's testimony in rebuttal (Vol. III, pp. 1916 to 1923) completely disposes of Becker's suggestion and demonstrates beyond question that the discharge in the August tubes was a pure electron discharge.

The next attack which defendant makes on Langmuir's work in November is based upon the fact that Langmuir was a highly qualified physicist and on the assertion that he was not producing practical results, but discovering scientific facts.

Langmuir is a great physicist, but he is also a great inventor of practical, useful things. We have said that August tubes were obviously capable of rectifying alternating current. The November tubes *did* rectify alternating current.

Petitioner next quotes from a note book entry which Langmuir made on March 23, 1913, and says it shows that it was not until that date that Langmuir had any conception of the invention.

The quotation in the petitioner's brief is incomplete. What follows in the note book entry makes it perfectly clear (Plaintiff's Exhibit 131, Physical p. 34):

> "It may be that an audion so made (if of the same dimensions and design as the DeForest) will not be as sensitive as the DeForest but by proper design (*i. e.*, making grid close-meshed, and perhaps using double grid, and by making the distances very small by using spacing devices, etc.) I expect to very greatly increase the sensitiveness

(this we have already done with No. 2 which appears to be three or four times more sensitive than the DeForest audion)."

No. 2 was a three-electrode or audion type tube which White had made under Langmuir's direction for Alexanderson. The evidence is positive that it operated by pure electron discharge (Vol. II, pp. 1191-1198).

In view of the fact that Langmuir had a tube in August, 1912, which did operate by pure electron discharge, that he made three tubes in November, 1912, which operated the same way, that Sweetser made another tube in November which also operated the same way, that Langmuir had given to Richardson in November, 1912, a pure electron discharge tube, had fully disclosed his invention to Coolidge in December, 1912, and to White in February, 1913 (I. R. pp. 1640-43; Vol. III, pp. 1468-70), and had made and operated three-electrode tubes for Alexanderson early in March, 1913, this note book entry cannot possibly mean that he had no conception of the invention until that date.

The entry is perfectly clear when read in connection with Langmuir's previous work. Both the two-electrode tubes and the three-electrode tubes which he had constructed up to that time had filamentary anodes, instead of the plate anodes of the commercial Fleming valve or DeForest audion. This was an expedient to which Langmuir resorted because of the difficulty of cleaning up a solid anode, something which he had tried to do and failed.

Therefore, all that this entry can possibly mean is that on March 21, 1913, at a time when he had constructed and operated both two-electrode and three-electrode pure electron discharge tubes *with filamentary anodes*, Langmuir

recorded his determination to construct a pure electron discharge, three-electrode tube with the *plate anode* of the conventional DeForest audion.

Arnold's Work.

The Court of Appeals of the District held that Arnold did not conceive the invention until long after Langmuir's reduction to practice (Op. pp. 94-5).

Arnold's alleged conception.

Arnold's so-called conception of the invention was nothing more than a DeForest audion operating at a somewhat higher voltage than 40 volts. His whole idea was that, if he took out "more of the residual gas" (Vol. I, p. 414) he could raise the voltage at which blue glow appeared. As he himself said (I. R. p. 2166):

> "We observed at this time that the blue haze appeared when an attempt was made to operate the tube at higher voltages than about 40 volts; and *in connection with my disclosure to him, that there would not be any blue haze if proper precautions were taken to remove the gas,* I also pointed out that *this* would enable us to operate the tube at higher voltages and that this operation at such a high voltage would retain *the advantageous characteristics of operation already obtained at low voltages,* while giving greatly increased output and allowing proper operation over a wider range of input voltages."

Arnold did not know that when the audion operated, as it normally operated, at voltages below the voltage at which blue haze appeared, it was dependent upon gas ionization, and he did not know that the erratic behavior and the necessity for critical adjustment to which Jewett

referred were due to gas effects which were *not* manifested by blue haze (*supra*, p. 41). On the contrary, he thought and said that when the audion was operating with the plate voltage carefully adjusted to the optimum value "the action was purely electronic" (I. R. p. 24).

As Langmuir said (I. R. p. 2057):

> "Arnold frequently speaks of audions in a way which indicates to me that his viewpoint in regard to the development of these tubes has been very different from mine. For example, on page 39 [I. R. p. 2193], he says:
>
> "'the principles of operation of the high vacuum repeater bulb that I contemplated were the same as for the original DeForest and McCandless audions, such as DeForest Audion 7-A, *when they were kept below the voltage at which gas effects appear.*'
>
> "(Page 41) [I. R. p. 2195]:
>
> "'Being interested in the operation of the DeForest tubes at voltages below those at which gas effects became apparent, I took the data,' etc.
>
> "From these and similar statements it is clear that Arnold retained the viewpoint that he had in November, 1912, where he observed a blue haze in the neighborhood of 40 volts and noticed that different tubes showed this blue haze at different voltages. He felt therefore that all he needed to do was to lower the gas pressure a little so that he could raise this voltage from 40 to 100 volts, and then his problem would be solved. He did not have in mind any new and fundamental modification involving a new type of discharge."

Arnold had no conception of a new type of discharge. His conception, if he had been able to realize it, would

have resulted in nothing more than a DeForest audion with the same erratic characteristics and with the same critical adjustment of voltage to the optimum value except that the optimum value might be somewhat higher.

This is not the invention; Arnold's alleged conception was therefore not a conception of the invention.

And Arnold's subsequent work showed that he had no conception of a tube which would operate steadily and reproducibly at any voltage. His test of a good tube was the voltage at which it showed blue glow (I. R. p. 2023). He was quite satisfied if he could raise the voltage at which blue glow appeared, notwithstanding the current was irreproducible at any voltage substantially above ionization voltage.

Accordingly Arnold regarded a tube as a good tube if it did not show blue glow at voltages in which he was interested, and he testified in this suit that one such tube showed a pure electron discharge up to 240 volts (Vol. I, p. 611), although, as he had to admit on cross examination, the curves which he produced showed that the current was completely irreproducible above 23 volts (Vol. II, p. 657; See also I. R. p. 2068).

Arnold's idea of means.

The Board of Examiners in Chief held that Arnold's alleged conception of November 1, 1912, was incomplete in that it included no adequate idea of means (Op. p. 68).

Petitioner seeks to meet this by quoting from the opinion of the Assistant Commissioner to the effect that if anyone conceived the idea that a rubber button was a good thing, he could go to a rubber manufacturer and have him make a rubber button and that this would be inven-

tion. But in this case there was no manufacturer to whom Arnold could go; the normal man skilled in the art did not know how to make such a "button."

Moreover, Arnold did not propose to rely upon the skill of someone else to reduce his invention to practice. He himself was the man skilled in the art, and as part of his disclosure he stated very definitely his idea of means, which was merely to exhaust the DeForest audion by the technique which he used in exhausting his mercury arc rectifier, supplemented by the use of liquid air and charcoal. It is not possible by these means to turn a DeForest audion into a Langmuir tube (Vol. III, p. 1913; Vol. III, pp. 1726-9; I. R. pp. 1101-2; I. R. p. 2055). Moreover these are not the means which Arnold now says he later used in his reduction to practice.

Neither in his disclosure of November 1, 1912, nor in the records of his later work prior to a note book entry of one of Arnold's assistants dated in October, 1913 (Vol. III, p. 801; Vol. IV, p. 327, No. 63), did Arnold make any reference to this new idea of means which he now says he used in his reduction to practice.

Petitioner's explanation for this striking circumstance is that Arnold simply followed a procedure which was such well known and standard practice that nobody would think of recording it. This explanation is emphatically contradicted by the fact that some three years later Arnold applied for a patent upon this very procedure, claiming it as an invention, and testifies that when he filed his application he regarded it as an invention, and something different from his mercury arc technique (Vol. II, pp. 785-786).

Therefore the petitioner's position amounts to this, that a conception and disclosure are complete although they

contain no idea of means and although the necessary idea of means involves something so novel as to be the proper subject of a patent.

And that Arnold did not have any adequate idea of means, and that the knowledge of men skilled in the art was not sufficient to supplement the inadequacy of his disclosure, is conclusively demonstrated by his first attempts to make some good tubes. In December, 1912, he instructed Trimble to "repump some of the DeForest or McCandless make of audions to see if we could get any better vacuum in them" (I. R. p. 2246).

This was after Arnold's alleged reduction to practice. Trimble was a man highly skilled in the art; he was the man who had been carrying out the mercury arc exhaust for Arnold. He tried to repump some of the DeForest audions to see if he could get any better vacuum in them *and he failed dismally.*

Arnold excuses Trimble's failure by saying that "a very important part of the procedure is to learn how to so conduct the exhaust that the filament will not be destroyed during the exhaust" (Vol. II, p. 749). This was something which Trimble still had to learn in December, 1912. Just when and where Arnold learned it we are not told; certainly he did not learn it from his mercury arc work, which involved no such problem, because the mercury arc has no filament. It is, however, vitally significant that Arnold never succeeded in making any good tubes until after Langmuir's Physical Review paper was published.

Arnold's later work.

This is enough so far as conception is concerned. Arnold's alleged reduction to practice by Audion 7-A is too late. His preliminary statement sets it at November 29,

1912 (I. R. p. 2156). As the Board of Examiners in Chief held (Op. p. 69), it was at best a mere accident which he did not appreciate and which he could not repeat.

The results of that accident are discussed by Langmuir at I. R. pages 2027-2042. The day after the test on which petitioner relies another test showed that the tube was again a very gassy tube. So it was not reproducible (I. R. p. 2031).

Arnold has been inconsistent about many things; strikingly so in connection with his Audion 7-A, where he has reversed his position not once, but twice, as the exigencies of his case seemed to require.

When Arnold swore to his preliminary statement in the interference, he relied on the November 29, 1912, tests of his audion as his reduction to practice of the invention.

When, on his motion to dissolve the interference, he was contending that there was no invention, he produced these same tests as characteristic of a typical prior-art DeForest audion (I. R. pp. 470-477).

And when, on priority in the interference, he again decided to claim that he was the inventor, he again produced these same tests as proof of his reduction to practice, and testified that the tube "did not belong in the same class with the original DeForest audions" (I. R. p. 2182).

And again in the present case he presents these tests as proof of his reduction to practice of the invention.

In February, 1913, Arnold staged a demonstration for the purpose of proving the practicability of transcontinental telephony with his new relays. Although he claims to have reduced to practice in November, 1912, he used in this demonstration not tubes of the invention, but old-style DeForest audions, and in order to adapt the transmission to the limited energy capacity of the

audions, the power level was kept much lower than on a commercial line, and he used some of his mercury arc repeaters at the end of the line in order to get the necessary amplification in the receiver.

But while a low power level was possible in a laboratory experiment, it would have been impracticable in an ordinary commercial line, as Arnold testified (Vol. II, p. 742).

It is incredible that if Arnold had conceived the invention and reduced it to practice months before, he would have been satisfied by a demonstration so inconclusive as this.

Petitioner says on page 77 of its brief that this demonstration was "a distinctly by-the-way incident, and not at all an important or official test." Arnold's testimony in the interference, I. R. page 2199, is:

> "It was a somewhat spectacular demonstration as is evidenced by the circumstance that President Vail of the American Telephone and Telegraph Company and other notable officials of that company and of the Western Electric Company witnessed the demonstration. It was the first test of an equivalent of the transcontinental line that had ever been undertaken."

Arnold staged another important, but less spectacular, demonstration in October, 1913. In September his assistant Kendall installed a repeater at Philadelphia, using some of Arnold's tubes. After more than a month spent in testing and adjusting, the repeater was switched in on a line between New York and Washington and it worked—exactly as the DeForest audions had worked in the February demonstration.

Kendall's written instructions for the use of these tubes specified plate voltages of about 30 to 50 volts, just what

was used with the old DeForest audions, *and the record of this test shows that the voltage on the tubes was being constantly adjusted.* Moreover Kendall's instructions specified the use of a protective device, a device on which Arnold later filed a patent application. In his application, which was filed April 16, 1914, describing his device he says (I. R. p. 2345):

> "It has been found in the usual audion structure that when energies of considerable magnitude, *such, for instance, as are encountered in ordinary telephone systems,* are impressed upon the input circuit of the audion, *a blue haze appears in the bulb of the audion.*"

Arnold's dream in November, 1912, was an audion which would handle the energy required for an ordinary commercial line, which was about 1 watt. In October, 1913, he had succeeded in producing some tubes which handled something less than .005 of a watt. At about the same time Langmuir was working with two kilowatts at 40,000 volts in a single tube (Vol. III, pp. 1460-61).

If Arnold had made any invention by October, 1913, it was not in improving the DeForest audion, but in redesigning the telephone circuits so as to adapt them to the limits of the old DeForest audion.

In October, 1913, as we have seen, Langmuir orally summarized (Vol. III, p. 1405, XQs639-641) his paper published in the December, 1913, issue of the *Physical Review.* Arnold was present (I. R. pp. 478 and 1596). About December 1st the *Physical Review* paper appeared. A few months later Arnold's people had some good tubes, capable of handling about half a watt (Vol. II, p. 725, XQ641). A few months after that the San Francisco line was operated with pure electron discharge tubes (Vol. I, p. 526, Q221, and p. 529, XQ241).

POINT V.

The rule of Adamson v. *Gilliland has no application in this case. (Petitioner's fifth point.)*

From what we have said above it is clear that this case turns on inferences or conclusions to be derived from substantially undisputed facts, and not upon findings of fact based upon conflicting testimony. Such being the case, the conclusions of the trial court are not binding on this Court (*The Britannia*, 153 U. S. 130; *Harkin* v. *Brundage*, 276 U. S. 36; *Corona Tire Co.* v. *Dovan Chemical Corp.*, 276 U. S. 358, 375).

Moreover, on the issue of priority the concurring decisions of the Examiner of Interferences, the Board of Examiners in Chief, the Court of Appeals of the District of Columbia and the United States Circuit Court of Appeals for the Third Circuit certainly outweigh the authority of the trial court.

On the issue of prior use the testimony was not taken before the Court, so that the rule of *Adamson* v. *Gilliland* (242 U. S. p. 350) would not apply in any event.

POINT VI.

The defense of double patenting has not been sustained by any judge who has heard this case, and is utterly without merit. (Petitioner's sixth point.)

On December 10, 1912, Langmuir disclosed to Coolidge the invention of the pure electron discharge tube which he had made and suggested to Coolidge that he attempt to apply that invention to the X-ray tube with which Coolidge at that time was very familiar.

Petitioner asserts in its brief that the only thing which Langmuir told Coolidge at that time was that tungsten would emit electrons in high vacuum. But Coolidge testifies that on that day Langmuir told him (Vol. III, p. 1512):

> "That when these filaments had been carefully freed from gas in a high vacuum, he had found it possible to maintain a discharge, a pure electron discharge, from a hot filament, that the electron emission had instead of decreasing with the removal of gas from the tungsten filament, which was to be used as a cathode, had increased up to a certain point, and from there on it remained steady, and that this was a thoroughly reproducible condition."
>
> "how he had freed what he was handling of gas and water vapor in order to get the high vacuum" (p. 1549)
>
> "to produce a new X-ray tube operating on a new principle, on pure electron flow" (p. 1549).

We proved this as a complete disclosure on December 10, 1912, of Langmuir's invention to a competent scientist who was capable of understanding it.

Langmuir did not invent the Coolidge X-ray tube; nobody ever contended that he did. But he disclosed to Coolidge an invention which he, Langmuir, had made and reduced to practice,—the invention of the pure electron discharge tube, and he also suggested to Coolidge the use of the principle of that tube in an X-ray tube.

It was not an easy suggestion to realize; Langmuir admits that he would have then been unable to realize it himself (Vol. II, p. 1295). Coolidge did realize it, after long and difficult research (Vol. III, p. 1520), and he revolutionized the X-ray technique to an extent which can best be appreciated by reference to I. R. pp. 1679-

1682, from which it appears that the advantages of reproductibility, reliability, etc., so important in the use of Langmuir's tubes in the radio art, are even more important proportionately in the X-ray art.

The prospect of an instrumentality so useful in relieving human suffering led to a rapid development and early commercial use of the Coolidge tube. A patent application was filed for it on May 9, 1913. The claims submitted with the application show that whoever prepared it assumed that Coolidge was the inventor of whatever was common to his tube and Langmuir's tube. The basis of this may have been some notes made by Coolidge in May, 1912 (Vol. III, pp. 1506-1508).

It is clear on the record that Coolidge was not the first inventor, that his crucial experiment made in September, 1912, caused him to feel that he had failed flatly—and he stopped (Vol. III, p. 1561), only to take the matter up when Langmuir's invention was disclosed to him a few months later.

Accordingly, when the true facts were ascertained, the Coolidge claims were limited to the X-ray tube which he had invented, and in the Coolidge specification were inserted the words which now appear in the Coolidge patent (Vol. VI, p. 1026, l. 64):

> "Certain broad aspects of the apparatus and methods herein disclosed are not of my invention but are the invention of Irving Langmuir and are defined by the claims of his allowed application, Serial No. 84,242, renewed March 14, 1916, and his application, Serial No. 876,432, filed December 10, 1914."

This obviously prevents any claim from the Coolidge patent being interpreted as broad enough to cover the

Langmuir tube. There is, therefore, no double patenting under the well-known doctrine set forth in Judge TAFT'S decision in *Thomson-Houston* v. *Ohio Brass Company*, 80 Fed. 712 (C. C. A., 6th).

The "prolongation of the monopoly" is inherent in any case where the fundamental patent and the patent on an improvement issue at different dates, as they normally do, and are assigned to the same assignee. During the life of the broad patent no one can lawfully use the broad invention without license. During the life of the narrow patent no one can lawfully use the narrow invention without license. If it happens that the same assignee owns both patents, as it often does, then the period in which that assignee has the right to keep everyone else from using the narrow invention is the longer period during which either one of the patents is alive (*Ohio Brass* case, 80 Fed. at p. 727). As the Court of Appeals for the Sixth Circuit said in *Dayton Fan & Motor Co.* v. *Westinghouse Electric & Manufacturing Company*, 118 Fed. 562, 571:

> "And no valid reason exists why the patentee of an invention may not enjoy the privilege of a stranger in thereafter obtaining a patent for an independent invention made by him, although it relate to the matter of his former patent, and was described, but not claimed, therein, provided he has not dedicated such independent invention to the public";

And as Judge LEARNED HAND held in the Southern District of New York, in *Van Heusen Products, Inc.* v. *Earl & Wilson*, 300 Fed. 922:

> "There is no case in the books to which I have been referred which holds that the defense of double patenting applies between two independent

inventors, merely because one has taken an assignment of the other invention. Nor is there any reason on principle to hold anything of the sort. The assignment makes no difference; each patent standing precisely as if there had been none such. The earlier inventor should and will prevail, if the inventions are the same; if they are different, both ought to stand. The only reason whatever for the defense of double patenting is that, since the inventor is the same in each, the defense could not succeed that the inventor of the second was not the first inventor."

If Coolidge made no invention, which we deny, then the Coolidge patent is invalid, and created no monopoly, but that would not affect the Langmuir patent (*Ohio Brass* case, at p. 727). If Coolidge made an invention, there is no reason why his assignee should not have a monopoly of it, as well as a monopoly of Langmuir's different and broader invention.

CONCLUSION.

The framers of our Constitution in their great wisdom foresaw the importance of stimulating and encouraging inventive skill and energy; accordingly they wrote into the Constitution a provision giving to Congress the power to promote the progress of science and useful arts by securing for limited times to authors and inventors the exclusive rights to their respective writings and discoveries.

The wisdom of this farsighted provision is abundantly attested by the amazing progress of science and the useful arts, particularly in the last quarter of a century. This progress has been due in large measure to the organized research work which is constantly being carried on in

large corporations like the Telephone Company, the General Electric Company, du Pont and many others.

In his speech on the occasion of the Edison celebration, President Hoover said:

> "If we would have our country improve its standards of living and at the same time accommodate itself to the increasing population, we must maintain on an even more liberal scale than before our great laboratories of both pure and applied science."

Relying on the promise held out by the Constitution and assured by the patent statutes, the respondent many years ago organized and has since maintained a wonderful research laboratory, dedicated to the creation of useful inventions for the immediate benefit of itself, but for the ultimate benefit of the country and all mankind.

The invention here involved is perhaps the greatest of the many great inventions which have emanated from that laboratory.

The arguments advanced to defeat the patent are specious; the principal argument is predicated upon the assertion of scientific fact which finds no support in the record and is contradicted by petitioner's own witnesses.

But as this Court said in *Diamond Rubber Co.* v. *Consolidated Rubber Tire Co.*, 220 U. S. 428, at 435:

> "But the law has other tests of the invention than subtle conjectures of what might have been seen and yet was not. It regards a change as evidence of novelty, the acceptance and utility of change as a further evidence, even as demonstration."

This language is singularly apt. The utility of Langmuir's invention is attested by the statement of Judge Morris that the Langmuir tube

"because of its stability, reproducibility and power has made possible radio broadcasting, modern radio reception and long distance telephony."

Its novelty is demonstrated by the fact that the practical workers of the art had failed to develop such a device at a time when the progress of the art was standing still. Its novelty is further convincingly demonstrated by its universal acceptance in preference to the old art devices, yet these old art devices, which long ago were abandoned in practice, are now resurrected and produced as a complete anticipation of the invention.

If a patent on a meritorious invention can be destroyed by mere plausible talk, by mere reiterated assertion of things which are not so, then the promise which the Constitution held out for meritorious invention is a false promise, and the promotion of science and the useful arts and the progress of industry must inevitably suffer.

Respectfully submitted,

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